

UNITED STATES DEPARTMENT OF AGRICULTURE

Soil Survey
of
Alger County, Michigan

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Bureau of Chemistry and Soils

In cooperation with the
Michigan Agricultural Experiment Station and the
Michigan Department of Conservation

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SOIL SURVEY OF ALGER COUNTY, MICHIGAN

By J. O. VEATCH, Michigan Agricultural Experiment Station, in Charge, L. R. SCHOENMANN, Michigan Department of Conservation, and F. R. LESH and Z. C. FOSTER, United States Department of Agriculture

COUNTY SURVEYED

Alger County is in the north-central part of the Upper Peninsula of Michigan, bordering the shore of Lake Superior (fig. 1). Munising, the county seat, is 44 miles east of Marquette and 123 miles west of Sault Sainte Marie by railway, and 50 miles and 129 miles distant, respectively, by automobile highway. The area of the county is 912 square miles, or 583,680 acres.

Physiographically Alger County lies in the Great Lakes plains region, which is the glaciated part of the great central lowland, or Mississippi plains region, of the United States. It is in the eastern, or lowland plains, part of the Upper Peninsula of Michigan, which is underlain by Paleozoic sedimentary rocks and is therefore contrasted with the western part, comprising a part of the Superior highland, which lies in general at a higher altitude and is largely underlain by a complex of igneous rocks and metamorphosed pre-Cambrian sediments. The northern part of the county is a sandstone plateau, and the central and southern parts are physiographically a cuesta underlain by limestones and having a northward-facing scarp.



FIGURE 1.—Sketch map showing location of Alger County, Mich.

The county as a whole is a plain, and although there are no marked differences in altitude, the surface relief presents a number of distinct topographic divisions of local significance and a diversity of natural features resulting from glacial action and postglacial erosion. The northwestern part comprises part of a plateau plain thinly mantled with stony sandy glacial drift, terraced near the lake shore, cut by streams, and dotted with bodies of wet land, owing to the fact that water is held by the underlying bedrock, but it contains few lakes. The southwestern part is a comparatively smooth plain mantled with clayey drift, featured by a few low gravelly ridges and by a large aggregate area of swamp. The north-central part, in the vicinity, south, and southwest of Munising, is rolling or hilly country characterized by deep sandy drift. The hills and ridges present an even skyline and have smooth rounded slopes. Associated with the hills are broad dry sandy valleys and plains. The southeastern part of the county is featured by extensive dry sandy hardwood and pine plains, by two conspicuous areas of sandy hilly up-

land, and by one very large wild difficultly accessible swamp covering about 6 square miles. Lakes occur in greater number than in any other part of the county. The eastern and northwestern parts comprise mainly a level plain dotted with low isolated hills and ridges, but in places many bodies of land are dry and pitted but otherwise nearly featureless. A large area of swamp and marshland, dotted with islands and low ridges of sand, lies east and northeast of Shingleton, and smaller wet areas are south and southwest of Grand Marais.

The shore line of Lake Superior is featured by bold precipitous bluffs of sandstone, ranging from 50 to 300 feet in height, notably on Grand Island and at the Pictured Rocks northeast of Munising. Two deep embayments, one at Munising and one at Au Train, are enclosed by hills and bluffs of sand, clay, and rock rising in terraces to a height ranging from 200 to 300 feet. The shore is further featured by low-lying sandy plains representing beach- and shore-line ridges of sand and gravel, by plains of sand representing stages in the glacial lakes preceding Lake Superior, by coastal lakes formed by the damming of streams by sand bars, and by the extensive sand dunes near Grand Marais. One large island, Grand Island, and three small low stony islands lie a short distance from the mainland north of Munising. Grand Island has much the same relief and features as the adjacent mainland. It is bordered by high sandstone cliffs on the northwest, but elsewhere the land rises by a series of rock benches, or terraces, to a height ranging from 200 to 300 feet above the level of the lake. The old rock surface is thinly covered with stony drift.

The general elevation¹ of the upland of Alger County is between 800 and 850 feet above sea level, or between 200 and 250 feet above the level of Lake Superior. The highest land, which is in the western and southwestern parts, ranges from 900 to probably a little more than 1,000 feet above sea level, and small morainic areas south of Munising in the extreme southeastern corner bordering Delta and Schoolcraft Counties, and areas southeast of Grand Marais, apparently also have elevations ranging from 900 to 1,000 feet. Narrow rock benches, terraces, and sandy plains bordering Lake Superior lie from 10 to 300 feet above the lake.

Streams are comparatively few in proportion to the total land area as the land surface is comparatively young. The streams have not had time to develop extensive dendritic systems, so that a large aggregate area of land is wet and swampy. All the streams flowing northward into Lake Superior are short and have a rapid fall. They have cut narrow gorgelike valleys, ranging from 100 to 150 feet in depth in places, into the plateau, and they are characterized by rapids and waterfalls. Those streams flowing southward into Lake Michigan are larger and longer, but they have not cut deeply and originate in or flow through swamps. The present surface configuration, comprising secondary topographic forms, is mainly the work of glaciers which filled the old valleys and left a mantle of glacial detritus of variable thickness over the whole county, although the old

¹ Detailed topographic maps are not available. The elevations are those given by Frank Leverett. In addition, a number of levels were determined by C. O. Wisler, hydrographic engineer, and aneroid measurements were made by S. G. Bergquist, geologist, during the progress of this survey.

preglacial land forms were not entirely obscured. Much of the level land, through which no streams flow, is comparatively dry, because of the underlying sandy soil and pervious sandy and gravelly drift. On the other hand, a large aggregate area of wet and swampy land occurs in flat areas where the water is held in pits and depressions in the underlying bedrock. Lakes occupy many of the depressions in the outwash plains and the moraines, and a considerable acreage of swamp land results from the filling of these lakes by vegetation.

With the exception of a few tracts of marsh and bog, which comprise only a small percentage of the county, the land was originally forested. The greater part of the forest has been cut over by lumbermen (pl. 1, *A*), although a few large tracts of virgin hardwood and swamp forest remain.

The original forest was represented by several types or associations of trees as follows: (1) The hardwood forest, which greatly predominated and in which the principal species were sugar maple, yellow birch, and beech, together with a variable amount of hemlock and a small amount of white pine; (2) the hardwood-conifer forest, which consisted of the common hardwoods, sugar maple, elm, basswood, ash, and yellow birch, mixed with white pine, balsam fir, hemlock, and spruce; (3) the pine forest, which consisted of red (Norway) pine and jack pine on the driest sand plains and ridges (pl. 1, *B*) and red pine and white pine on the slightly moister sandy soils; (4) the forest consisting of swamp conifers and hardwoods, such as ash, elm, balsam-of-Gilead poplar, red maple, white birch, and aspen on the wetter mineral soils; and (5) the coniferous peat-swamp forest including mainly white cedar, black spruce, and tamarack.

As throughout northern Michigan, where the land has been cut over by lumbermen and subsequently ravaged by fires, much of it is now occupied by a poor second growth of aspen, fire cherry, white birch, and only a few poor remnants of the original forests. On the wetter soils aspen is the predominant second growth, but in places there is a fairly thrifty and dense stand of balsam fir, spruce, and white pine. The driest pine plains, such as those lying south of Wetmore, and the White Rat Plains, southwest of Grand Marais, were probably never densely covered by forest, and the land is characterized by open spaces occupied by blueberries, sweetfern, bracken, reindeer moss, grasses, and sedges. The bogs supported a growth of leatherleaf, Labrador-tea, blueberries, cranberries, Sphagnum moss, and cotton grass, together with a few scattered small black spruce, and in the marshes various sedges and bluejoint grew.

Potable healthful water can be obtained from wells sunk to slight depths, in most places less than 100 feet, and in several places flowing artesian wells are obtained. The well water is soft along the Lake Superior shore, but that in the southern part of the county is hard from calcium and magnesium bicarbonates. Practically all the streams are perennial and carry clear cold water. Those flowing northward are characterized by falls and are sources of present and potential electric power. There are 286 lakes of considerable size in the county. These for the most part contain clear cold water.

The population of Alger County, according to the 1930 census,² is

² Soil survey reports are dated as of the year in which the field work was completed. Later census figures are given whenever possible.

9,327, of which 5,371 are classed as rural. The greater part of the population is native-born American, although the farm population includes 901 foreign-born whites, 1,575 of foreign or mixed parentage, chiefly Finnish and Swedish, and 532 of native parentage. The density of the rural population is 5.8 persons a square mile. Munising, with a population of 3,956, is the county seat and the only incorporated town in the county.

Lumbering and agriculture are the principal industries. Lumbering has declined within the last 10 years, although logging is still extensively carried on in the hardwood forests, and posts, railway crossties, and pulpwood are cut in the swamps. Large lumber mills and a paper and pulp factory are located in Munising. The value of forest products cut on farms in 1929 was \$58,192, and the total value of agricultural products the same year amounted to \$578,143.

Alger County attracts large numbers of transient hunters and fishermen, and during the summer the tourist trade is a considerable commercial asset. Commercial fishing in Lake Superior, and wild-plant products, such as blueberries, raspberries, ferns, and moss, are also sources of income.

Railway transportation is afforded by the Duluth, South Shore & Atlantic Railway; the Lake Superior & Ishpeming Railway; the Chicago and North Western Railway; and a branch of the Minneapolis, St. Paul & Sault Ste. Marie Railway. Water transportation on the Great Lakes is also available, and four State trunk-line highways provide for automobile traffic. All points in the county are accessible by county and private roads, although these are for the most part unimproved, and some of them may be impassable during the winter and spring.

CLIMATE

Alger County lies between parallels 46° and 47° north latitude. The features of the climate are a mean temperature of about 40° F., a normal precipitation (including melted snow) of approximately 32 inches a year, an average annual snowfall of 100 or more inches, high relative humidity, low percentage of possible sunshine, low wind movement, and low evaporation.

The winters are long, many of them extremely cold. Normally the mean temperature is below freezing from November to March, and a minimum of -44° F. has been recorded at Chatham. The summers are short and are characterized by moderate temperatures with a seasonal average of about 60° F.

Differences in temperature and time of frosts are great enough in different parts of the county to have considerable significance in relation to plant growth. The first killing frosts may be as much as one month later along the shore of Lake Superior than on higher land from 10 to 20 miles back from the shore. The average frost-free season, as measured between the last frost in the spring and the first in the fall is about 155 days at Grand Marais, but it is only 82 days in the west-central part of the county at Chatham, where light frosts have been known to occur in June, July, and August. Though the short growing season and low mean temperature back from the lake shore place this county at some disadvantage by limiting the diversity of crops and the maturing of corn and

fruit, in competition with counties in southern Michigan, the growth of hay, field peas, and small grains and the length of the pasture season are not greatly affected.

Precipitation is fairly evenly distributed throughout the year, but it is generally somewhat greater in the fall and summer than in the spring and winter. Most of the rains are slow and long continued, and sudden destructive downpours are rare. Considerable differences in the annual amounts are recorded, and short periods of drought sometimes occur. On the more pervious sands and gravels poor plant growth may be attributed to deficiency of moisture, but on the sandy loams sufficient moisture is generally available, and on the level clay lands there is more likely to be an excess than a deficiency.

The snowfall, which in most places forms a permanent cover from November to April, prevents freezing of the soil to a great depth during the winter and protects fall-sown grain.

The prevailing winds are from the west. Wind movement is generally low, but at times the wind attains a high velocity directly along the lake shore.

Tables 1 and 2, showing the more important climatic data, are compiled from records of the United States Weather Bureau stations at the Michigan Agricultural Experiment Station at Chatham, in the west-central part of the county, and at Grand Marais, in the northeastern corner on the shore of Lake Superior.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at Chatham, Alger County, Mich.*

[Elevation, 875 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1925)	Total amount for the wettest year (1915)	Snow, average depth
	° F.	° F.	° F.	Inches	Inches	Inches	Inches
December.....	19.7	56	-23	2.26	2.11	2.10	21.9
January.....	14.2	55	-34	1.97	1.77	2.75	18.5
February.....	13.3	52	-44	1.76	.91	3.40	17.6
Winter.....	15.7	56	-44	5.99	4.79	8.25	58.0
March.....	23.4	77	-33	1.54	.41	2.00	14.2
April.....	36.4	87	-18	1.97	.41	1.10	6.6
May.....	47.8	97	12	2.68	1.28	2.50	2.1
Spring.....	35.9	97	-33	6.19	2.10	5.60	22.9
June.....	58.5	97	23	3.39	3.97	5.70	0
July.....	63.4	101	29	3.58	1.51	4.10	0
August.....	61.2	94	27	3.15	2.05	5.23	0
Summer.....	61.0	101	23	10.12	7.53	15.03	0
September.....	54.4	92	21	3.83	3.16	5.04	0
October.....	44.2	87	5	3.07	2.34	3.21	2.2
November.....	32.9	69	-10	2.95	1.79	5.03	19.5
Fall.....	43.8	92	-10	9.85	7.29	13.28	21.7
Year.....	39.1	101	-44	32.15	21.71	42.16	102.6

TABLE 2.—*Normal monthly, seasonal, and annual temperature and precipitation at Grand Marais, Alger County, Mich.*

[Elevation, 610 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1921)	Total amount for the wettest year (1922)	Snow, average depth
	° F.	° F.	° F.	Inches	Inches	Inches	Inches
December.....	23.5	50	-11	2.78	1.62	5.57	24.8
January.....	16.7	46	-21	2.98	1.80	2.84	33.1
February.....	14.7	48	-23	1.94	.90	4.04	20.3
Winter.....	18.3	50	-23	7.70	4.32	12.45	78.2
March.....	25.0	68	-32	1.84	2.60	4.20	13.1
April.....	36.6	77	-7	2.12	.82	3.74	4.9
May.....	46.1	88	20	2.29	.84	3.57	.8
Spring.....	35.9	88	-32	6.25	4.26	11.51	18.8
June.....	55.8	94	30	2.74	2.21	3.78	0
July.....	61.7	98	29	2.66	1.32	3.17	0
August.....	62.2	92	31	2.37	1.09	1.55	0
Summer.....	59.9	98	29	7.77	4.62	8.50	0
September.....	57.5	90	32	3.08	3.39	4.03	(¹)
October.....	47.0	84	20	2.90	1.42	1.10	.7
November.....	35.3	66	8	2.66	1.50	2.66	10.7
Fall.....	46.6	90	8	8.64	6.31	7.79	11.4
Year.....	40.2	98	-32	30.36	19.51	40.25	108.4

¹ Trace.

AGRICULTURE

Agriculture in Alger County is comparatively recent. Though some patch farming and gardening was done around the earliest settlements, beginning about 1800, and later in the vicinity of the lumber camps and towns, few permanent farms were established prior to 1900.

In the early farming, hay was the principal crop, small fields of oats and potatoes were grown, and some common garden vegetables were produced, also maple sirup and maple sugar. During the last 10 years the tendency has been toward greater diversity of crops and an increase in dairying and livestock farming. Though there has been a slow increase in the number of farms since 1900, less than 10 percent of the total area of the county is in farms at present (1930). Most of the individual farms and separate fields are small because of the cost and labor of reclaiming land, which involves the removal of trees, stumps, and stones, and the installation of drainage. On the other hand, farming even on the small fields is not highly intensive, because the factors which induce intensive farming, namely, high prices and scarcity of land, large population, and local markets are absent.

The principal crops grown and their respective acreages and yields, as reported by the census, are shown in table 3.

TABLE 3.—*Acreage and yield of principal crops in Alger County, Mich., in stated years*

Crop	1919		1924		1929	
	<i>Acres</i>	<i>Tons</i>	<i>Acres</i>	<i>Tons</i>	<i>Acres</i>	<i>Tons</i>
Hay.....	4,684	5,684	8,873	10,025	7,770	11,392
		<i>Bushels</i>		<i>Bushels</i>		<i>Bushels</i>
Oats.....	1,045	26,882	1,527	61,962	1,513	51,817
Barley.....	266	4,539	158	4,988	764	22,674
Potatoes.....	446	37,694	537	63,757	553	59,050
Wheat.....	403	4,804	58	1,440	54	938

¹ In 1924 oats were cut and fed unthreshed from 429 acres and in 1929 from 66 acres.

Other crops grown with some measure of success in a small or experimental way are field peas, rye, buckwheat, alfalfa, rutabagas, turnips, sunflowers, corn (for silage), artichokes, vetch, and millet.³

Fruits can be grown for home use, but climatic and other conditions are unfavorable for extensive commercial orcharding. Apples and plums are grown with fair success, especially near the lake shore, and raspberries, gooseberries, and strawberries can be grown throughout the county. Many of the common garden vegetables, such as cabbage, onions, lettuce, radishes, and squash, can be grown, especially directly along Lake Superior, for home use and for sale on the local markets.

According to the 1930 census, the livestock in the county included 5,635 cattle, most of which were dairy cattle, 610 swine, 734 sheep, 578 horses, and 13,432 chickens. The value of dairy products sold in 1929 was \$223,934. Poultry and eggs are a supplementary source of income on most farms. Poultry raised in 1929 was valued at \$20,877, and chicken eggs produced were valued at \$35,605. Both sheep and cattle are pastured on uncleared land. Cut-over land, including wet mineral soils and the well-drained soils which are underlain by clay or clayey sand, where not too densely covered with brush and trees, afford good grazing from May to October or even to the first of November. In addition to native forage plants, timothy, alsike, and red clover grow wild or can be easily introduced on burned-over land by seeding without any soil preparation. The cut-over lands of the sandy plains and deeper sands on the hills afford poor or only fair grazing, and the virgin forests, both swamp and upland, have very little value for pasture.

Commercial fertilizers have not yet been used in any considerable quantity. Many farmers on newly established farms are not in a financial condition to buy fertilizers, and, because of economic conditions and the type of farming, no imperative need for greatly increasing yields is evident. However, as none of the soils is unusually productive, it does not seem probable that profitable productivity can be maintained for any great length of time without the use of some commercial fertilizer, in conjunction with the application of manure and the use of legumes to increase organic matter. Very little lime has been used, although practically all the soils are acid

³ Additional information on crops, tillage, and agricultural conditions, may be obtained from Special Bulletin 215, of the Michigan Agricultural Experiment Station, East Lansing, and from the Director of the Upper Peninsula Experiment Station at Chatham.

and would be benefited by the use of lime, especially where it is desired to seed alfalfa.

No common system of crop rotation or generally accepted procedure in handling soils has been developed from experience, as in regions where agriculture has been carried on for a long time. However, the value of changing crops, as opposed to continuous cropping, is recognized by most farmers, and some kind of rotation is followed, even though it is not systematic.

It is generally considered the better practice to plow the heavier soils in the fall rather than in the spring, but the lighter and drier soils may be plowed either in the fall or spring. The use of the cultipacker or a roller on the lighter sandy soils is probably advisable.

The farms are small, most of them ranging from 40 to 80 acres in size, with generally less than half the land in cultivated crops. The small size and irregular shape of fields are attributed to such factors as cost and labor of clearing land of stumps, trees, and stones, and to the general distribution of swamps and wet land. Most of the land is still held in large tracts by lumber and land companies and by National and State Governments in forest reserves and in game refuges.

The character of the soil, together with other factors, such as surface relief, accessibility, distribution, and virgin forest or cut-over condition of the land, has determined the present distribution of farming. The greater part of the farming is carried on in the western and southwestern parts of the county in the vicinity of Chatham and Trenary, where the soils are the most productive and where the relief is not excessively rough, although some of the land is very stony. There is a small farming community near Munising and Wetmore, where the location is favorable, the soils moderately fertile, and the land not excessively stony; a few farms are located north of Shingleton on the better sandy loams, where the land is not excessively rough or stony; a fourth farming area is adjacent to Grand Marais, where the climate is favorable, the land level and not excessively stony, and the soil moderately fertile and not excessively dry, but in part wet. Elsewhere in the county there are only a few scattered patch farms. The sandy plains, both hardwood and pine, are of poor or medium fertility and are deficient in moisture, and much of the land is remote and difficult of access. The sandy soils of the hills are, for the most part, of medium or low fertility and have the disadvantages of unfavorable surface relief; the plateaus of the northwestern part of the county are in general excessively stony, densely forested, or occupied by second-growth trees where the virgin forest has been removed, and they are in part wet and swampy, so that under present conditions little farming has been attempted.

An arbitrary separation of the land into three classes is presented in table 4.

TABLE 4—*Classification of land in Alger County, Mich.*

Soil type	Ap- proximate area	Class and description	Present use and ownership
Greater parts of the Trenary, Munising, Chatham, and Alger soils. Small parts of other soils included.	<i>Acres</i> 85,000	Soils of medium productivity, moisture good, not swampy, slopes not excessively steep, separate bodies large enough to warrant agricultural development, either not stony or other factors sufficiently favorable to warrant clearing of stones.	Greater part in farms or land owned in small tracts; estimated that from 40 to 60 percent is cleared land; remainder mainly second-growth forest or recently cut-over land; small percentage in stump pasture; approximately 10 percent in virgin forest.
Mainly Kalkaska, Au Train, Strongs, Hiawatha, Traunik, Longrie, Ontonagon, Emmet, Ogemaw, Bohemian, Burt, and Blue Lake soils. Some of the sandier and more steeply sloping land excluded.	230,000	Soils of medium productivity, but land value depreciated because of stones, steep slopes, hilly relief, or poor drainage; part of the land level and soil uniform but plant growth limited by low moisture supply.	Less than 2 percent cleared and cultivated; land owned in large tracts and valued chiefly for hardwood timber; cut-over land remains largely under private ownership, but is owned in part by State and National Governments.
Mainly Grayling, Rubicon, Saugatuck, Waiska, Rodman, Onota, Sheldrake, Wallace, Sauble, Deer Park, Granby, Newton, and alluvial soils; and peats and mucks.	268,000	Land value lowest because of low productivity, excessive stoniness, steep slopes, choppy relief, swampy condition, excessive dryness, occurrence in small bodies, or a combination of these factors.	Less than 1 percent in farms; valuable forest land still remains largely under private ownership; from 75 to 80 percent cut-over land which is still held in part in large tracts by land and lumber companies, but in part is under State and National Government ownership in forest reserves and game refuges; small part held by private hunting and fishing clubs.

This classification excludes values based on standing timber, minerals, urban land, and land for resort and club use, and is based primarily on relief, productivity, and tillage qualities of the land. Although the classification is not based primarily on the present money value, a fairly close relationship exists between the three classes of land and their present assessed values. Such classifications as the one here given, are, of course, not precisely quantitative and are subject to change as economic conditions and agricultural practices change. The classification here presented is made on a local basis. If it were made on a State-wide basis, the amount of first-class land would be smaller.

It is evident from the data set forth in table 4 that a considerable aggregate acreage of wild land remains, which is arable and locally first-class when its productivity is considered; also that there is a very large aggregate acreage of second-class land which is of little present value but is capable of being brought to a productive state and of being utilized in the immediate future, whenever actual need of it for agricultural production or for farm homes arises; but the third class seems to have little possibility of use other than for forestry, game preserves, and recreational purposes.

SOILS AND CROPS

Nearly 50 soils were identified in the survey of Alger County. They range widely in texture, structure, thickness, chemical composition, and moisture, and consequently in natural productiveness.

Throughout the greater part of the county, the soils occur in small bodies, in many places in complex associations, and they show the usual gradations in texture and other characteristics within short horizontal distances, a condition which is common to the soils of the State. The variable character and great number of distinct soils are attributed to the complexity of the glacial deposits which form a superficial layer over the old rocks, to the variety of topographic forms of glacial origin, and to the varied surface relief of the pre-glacial land.

The texture of the surface layers of the mineral soils, exclusive of forest litter and duff, ranges from loose, incoherent, nearly pure sand to silt loam and clay loam, but most of the mineral soils are sands and light sandy loams to a depth of more than 3 feet. The sands comprise about 5.5 percent of the total area of mineral soils, the sandy loams and loams comprise about 28 and 16 percent, respectively, and soils which would have a silt or clay loam texture in the plow soil, if cultivated, comprise less than 1 percent. The greater part of the land in the county, exclusive of swamp, is arable, although it is estimated that about 10 percent would be nonarable or very difficult to reclaim, chiefly because of extreme stoniness, susceptibility to blowing, and excessively steep slopes. The muck and peat soils have their own peculiar physical characteristics and problems of management, but in Alger County they have at present practically no value for cultivated crops.

The content of humus, or organic matter, in the plow layer in the greater part of the soils is, or would be if the land were cultivated, comparatively low. The forest litter and duff layer of the virgin well-drained soils is, or was originally, from 2 to 4 inches thick, but the humus-mineral layer in some soils is so thin as to be scarcely measurable. Some of the organic matter of the forest soil is lost in clearing the land, and that remaining is not durable under cultivation, especially in the sands. Although in a technical sense the soils are thin, generally the soil mass is deeply penetrable, as the underlying rock material is unconsolidated, consisting of ice- and water-laid drift and recent lacustrine, wind, and alluvial deposits. In a number of local areas either hard bedrock or hardpan lies within a depth ranging from 1 to 3 feet below the surface, although the aggregate area of such land amounts to less than 2 percent of the total area of the county.

Probably 98 percent of the soils are acid in reaction in the natural surface horizons of mineral soil. It is estimated that about 85 percent of the soils are acid to a depth ranging from 36 to 40 or more inches and from 10 to 15 percent are strongly acid at the surface but contain sufficient calcium and magnesium carbonates or sufficient limestone gravel at a depth ranging from 24 to 36 inches to give an alkaline reaction. Less than 2 percent are nonacid in the surface layers under natural conditions. Most of the organic soils range from medium to strongly acid. There is very little of the black loamy well-decomposed so-called "high-lime" muck which is common in the southern part of the State.

The soils, for the most part, are naturally fairly well drained, as the water table is not high and the slope is sufficient to provide free run-off. Over about 10 percent of the area of the county the soils

become excessively dry at times during the summer, but it is estimated that about 30 percent of the land is characterized either by a high water table or by a permanently swampy condition.

The natural fertility and productivity of the soils, according to the standards for the State, range from medium to low. Though analyses of the dominant types of soils in this county do not show any evidence of abnormally small amounts of the nutrient elements ordinarily determined, much of the soil is poor in productivity because of a combination of low or only medium content of plant nutrients and a deficiency of moisture, for example, the pine-plain sands. A considerable percentage is poor because of low content of mineral plant food and because of excessive water, as in some of the peats and swamp-land mineral soils such as the Saugatuck and Newton.

For the purposes of mapping and correlation, soils are grouped in series on the basis of common characteristics of color, consistence, texture, chemical composition, and thickness of the whole soil and the separate layers of the soil profile. The soil type, or unit of mapping, is distinguished on the basis of texture of the surface soil, or plow layer, of the mineral soils within the series. Each soil series is given a geographic name for convenience of reference and description.

In interpreting or drawing conclusions from the soil map it should be understood that in few places are the soil types sharply separated in characteristics but rather grade into each other, so that mathematically accurate lines of demarcation are not to be expected. Small areas of other soils and small variations are included in each soil division shown, so that each color or pattern on the map must be understood as representing a dominant soil condition and not in every instance a single type of soil strictly uniform in every respect. The amount of detail which can be shown is of course limited by the scale of mapping. The scale on the accompanying map is 1 inch to the mile, and on this scale it is not generally practical to attempt to accurately locate separate bodies of soil less than 5 acres in extent.

In regard to the use and value of the land the soils of the county are divided into the following groups on the bases of outstanding textural characteristics, surface relief, drainage, and natural vegetation: (1) Loam soils of the hardwood uplands, (2) sands of the hardwood and pine plains, (3) sandy loams and sands of the hardwood and pine hills, (4) stony loams and sandy soils of the plateau upland and rock benches, (5) lake-shore soils, (6) sandy and clay soils of the swamps and wet land, (7) stream-bottom soils, and (8) organic soils.

In the following pages of this report the soils of Alger County are described in detail, and their agricultural relationships are discussed; their location and distribution are shown on the accompanying soil map; and their acreage and proportionate extent are given in table 5.

TABLE 5.—*Acreage and proportionate extent of soils mapped in Alger County, Mich.*

Type of soil	Acres	Per- cent	Type of soil	Acres	Per- cent
Trenary loam	19,008	3.3	Longrie loam	6,400	1.1
Trenary loam, shallow phase	5,248	.9	Deer Park fine sand	1,920	.3
Trenary fine sandy loam	20,544	3.5	Sauble fine sand	2,560	.4
Rodman stony loam	1,088	.2	Alger loam	3,584	.6
Au Train loamy sand	62,912	10.8	Waiska gravelly sandy loam	3,136	.5
Kalkaska loamy sand	50,560	8.7	Sheldrake sand	6,336	1.1
Kalkaska fine sandy loam	2,304	.4	Coastal beach	1,088	.2
Grayling sand	3,584	.6	Newton sand	11,840	2.0
Rubicon sand	40,832	7.0	Munuscong fine sandy loam	6,976	1.2
Trautnk loamy fine sand	1,472	.3	Saugatuck sand	22,592	3.9
Blue Lake loamy sand	9,280	1.6	Ogemaw fine sandy loam	11,200	1.9
Hiawatha loamy sand	15,296	2.6	Ontonagon clay loam	320	.1
Hiawatha fine sandy loam	320	.1	Brimley fine sandy loam	640	.1
Hiawatha sandy loam	4,864	.8	Burt loam	1,344	.2
Bohemian fine sandy loam	9,920	1.7	Ewen loam	640	.1
Strongs loamy sand	31,104	5.3	Griffin loamy fine sand	960	.2
Strongs fine sandy loam	1,728	.3	Carbondale muck	76,736	13.1
Wallace fine sand	960	.2	Houghton muck	2,560	.4
Emmet loamy sand	1,472	.3	Kerston muck	3,264	.6
Emmet sandy loam	1,280	.2	Rifle peat	6,976	1.2
Munising loam	30,528	5.2	Spalding peat	13,696	2.3
Munising loam, poorly drained phase	832	.1	Greenwood peat	6,528	1.1
Munising sandy loam	23,424	4.0	Tahquamenon peat	2,176	.4
Onota stony fine sandy loam	42,944	7.3	Rock outcrop	328	.1
Chatham stony loam	8,576	1.5			
			Total	583,680	

LOAM SOILS OF THE HARDWOOD UPLANDS

The high, comparatively smooth upland plains underlain by stony red clay, as in the country west of Chatham in the western part of the county, in the vicinity of Trenary in the southwestern part, and the smaller area in the east-central part east of Munising and north of Shingleton, are characterized by productive loamy soils which originally supported dense hardwood forests. A large part of the land has little present agricultural value, as it consists of peat swamps and wet clay land, which remain uncleared, but much of the smooth or gently rolling higher land is cleared and farmed, although locally some of it is excessively stony.

The soils of the better drained but smooth land are members of the Trenary series. These soils are distinguished by the presence of a large quantity of limestone in the gravel and stones and by the limy character of the underlying clay, differing in these respects from the red sandy clay soils farther north on the tableland bordering Lake Superior. Two types and one phase of the Trenary soils were identified, based on textural differences in the surface layers and depth to the clay—Trenary loam; Trenary loam, shallow phase; and Trenary fine sandy loam. These soils originally supported a fine forest consisting mainly of sugar maple, beech, yellow birch, elm, basswood, balsam fir, and hemlock. Most of the land has been cut over, but only about 50 percent of it has been cleared for farming. Rodman stony loam is the fourth member of this group.

Trenary loam.—Trenary loam includes the heavier Trenary soil which is loam or silt loam in the plow layer. The subsoil is also heavier, or less sandy, and is reached at a slighter depth, from 10 to 20 inches, than in Trenary fine sandy loam. The undisturbed, or virgin, soil consists of a 2- or 3-inch layer of forest mold and humus underlain by a thin gray silt or fine sandy layer, and this, in

turn, by a yellowish- or cinnamon-brown silty layer overlying red sandy clay. When the land is first cleared and plowed, the soil is variegated in color but, if thoroughly mixed, is light brown when dry. This soil is fairly well supplied with organic matter, retains moisture well, is not excessively acid, has good tilth, and is otherwise moderately productive. Most of the land is stony.

Fair yields of timothy and clover hay, potatoes, oats, and barley are grown. It is estimated that about 25 percent of the area of this soil consists of cut-over forest land or wood lots. The value of much of the land is depreciated by its occurrence in small bodies penetrated or surrounded by swamp and wet land.

Trenary loam, shallow phase.—In a few areas of Trenary loam limestone bedrock is present at a depth ranging from 3 to 4 feet or less. Such areas are indicated on the soil map as Trenary loam, shallow phase. The subsoil material is generally more plastic and less pervious than that under the deeper Trenary soil. Consequently drainage is slower, but no considerable difference exists in agricultural value between the phase and the typical soil.

Trenary fine sandy loam.—Trenary fine sandy loam differs from Trenary loam in the sandier texture of the surface soil; otherwise the soil is very similar to the loam and has about the same agricultural possibilities. The principal area lies a few miles north of Shingleton. The original forest has been cut over, and a small part of the land has been cleared and farmed, but the greater part remains in second-growth timber.

Rodman stony loam.—Rodman stony loam includes the soils of the narrow sharp stony ridges and knolls, associated with the level or gently rolling stony clay plains of the southwestern part of the county. The underlying material is a pervious heterogeneous deposit of boulders, cobbles, gravel, and sand, with only here and there sufficient clay to slightly bind the coarse material. Limestone boulders and smaller limestone fragments are characteristic, as in Chatham stony loam, but because of the difference in relief, this soil is less loamy and less uniform, and the brown color is not so marked. The land is capable of supporting a fair growth of hardwood forest and when cleared of trees and brush furnishes good pasture, but it is of little value for cultivated crops because of extreme stoniness, unfavorable relief, and susceptibility to erosion.

SANDS OF THE HARDWOOD AND PINE PLAINS

The sand soils occupy a large aggregate acreage, but they are generally regarded as inferior for agriculture, comprising second- and third-class land. They originally supported nearly pure stands of red (Norway), jack, or white pine or hardwoods, and mixed stands of hardwoods, white pine, and hemlock. Most of the land is level or slightly undulating, but in places it is pitted and marked by shallow dry valleys, with short abrupt scarp-like slopes.

A number of soils are distinguished on the basis of slight differences in texture, in the thickness and color of the brown or yellow sub-surface layer which is common to all the old soils of this section, and on the basis of the extent of limestone influence in the underlying material. Corresponding to these differences is a slight range in the average moisture content, in the productivity, and in the natural

suitability for plants. All the soils of this group, however, have the same general profile, all are underlain by loose dry yellow and gray sand to a depth of several feet, all are characterized by medium or strong acidity in the surface layers, and all have a thin layer of forest mold or duff and the practical absence of a dark-colored humous surface soil. The principal limiting factor in plant growth is low average moisture content.

The soils in this group are Au Train loamy sand, Kalkaska loamy sand, Kalkaska fine sandy loam, Blue Lake loamy sand, Rubicon sand, Grayling sand, and Traunik loamy fine sand.

Au Train loamy sand.—Au Train loamy sand is characterized by a thick rust-brown or yellow slightly cemented layer of sand or hardpan beginning at a depth between 6 and 12 inches. This layer is thicker than the surface soil, in most places reaching a depth ranging from 30 to 40 inches, and in places the material is colored to a depth between 5 and 6 feet, and is consequently more noticeable than in the other sand soils of the group. The soil is strongly acid, and very little or no limestone, or calcium carbonate, occurs in the underlying dry sand and gravel.

This soil occurs only in the northern and northeastern parts of the county, where it occupies nearly level land on the benches and high plains bordering Lake Superior. The land originally supported a good stand of hard maple, yellow birch, hemlock, and beech, together with scattered large white pine and fir. A few small areas of virgin forest remain, but the greater part of the land is now occupied by a second growth of the original species, together with aspen, cherry, red maple, and service berry, with a fair grass cover on the more open land. The land is arable, although very little of it has been placed under cultivation. It is probably capable of producing fair yields of cultivated crops, such as hay, potatoes, oats, and root crops, if heavily manured or fertilized, but it is regarded as second- and third-class land under present economic conditions. The grazing value is poor or only fair.

Kalkaska loamy sand.—Kalkaska loamy sand is distinguished by a small amount of limestone gravel in the underlying sand and by the dark-brown color and loamy feel of the sand which begins at a depth ranging from 4 to 8 inches. This soil occurs in fairly large and uniform bodies on the level plains, terraces, and dry valleys in the central and southern parts of the county. The original forest consisted mainly of hard maple, yellow birch, hemlock, beech, and elm, with a variable admixture of white pine. The soil is capable of producing fair yields of oats, potatoes, and the other crops adapted to this section, although none of it is under cultivation at present. The grazing value of cut-over land is poor or only fair, and on the whole the soil is regarded as second-class land. In places the soil is unusually gravelly and cobbly at the surface; such areas are indicated on the soil map by gravel symbols.

Kalkaska fine sandy loam.—Kalkaska fine sandy loam has a light-gray fine sandy loam or loamy fine sand surface soil which extends to a depth of 8 or 10 inches. This is underlain by a brown fine sandy loam subsoil which extends to a depth of 15 or 18 inches. The slightly finer texture and slightly higher moisture retentiveness differentiate this soil from the other sand soils of the group, as the underlying material is medium and coarse dry sand.

The original forest growth was principally hardwoods, maple, beech, and birch, with some admixture of hemlock and white pine. All the land has been cut over and is now in second-growth trees, with the usual aspen, cherry, and red maple, which follow lumbering and fires. The more open land supports a fair grass cover. A few small fields were at one time in cultivation, but none of the land is now in use. This soil is probably capable of producing fair yields of crops, but the value of the land is low, because of remoteness from markets and comparatively small acreage.

Grayling sand.—Grayling sand comprises the deep yellow sands of the drier pine plains. The accumulation of organic matter on the surface and the organic and iron oxide coloration in the subsurface soil are less than in other sand soils of this group. The land has very little agricultural value because of the low moisture-holding capacity of the soil, its single-grain, or incoherent, structure, looseness, and tendency to blow.

The natural tree growth apparently consisted mainly of red (Norway) pine, with a smaller amount of jack pine and white pine. At present the growth includes a few isolated individual red pines, a few jack pines, oaks, and a sparse growth of aspen. On the more open land, blueberries, sweetfern, bracken, sedges, and grasses, such as wild oats and bunch grass, grow, and in drier or more barren places, lichens. The pasture value of the land is low, and the rate of tree growth apparently is slow.

Rubicon sand.—Rubicon sand is characterized by a gray sand layer to a depth ranging from 4 to 6 inches. This is underlain by dull-yellow or brown sand, which may be slightly cemented, extending to a depth ranging from 18 to 24 inches. This soil is intermediate in the development of its gray and brown layers between the Grayling soils and the Au Train soils. Rubicon sand is highly acid and low in fertility, but it possibly supports a little heavier growth of vegetation than Grayling sand, because of its slightly higher average moisture content.

The original forest growth was chiefly white and red (Norway) pine, with a small admixture of the common hardwoods. The present growth consists of aspen, red maple, service berry, cherry, and white and red pines as scattered individuals. The ground cover is mainly sweetfern, blueberries, bracken, wintergreen, mosses, and lichens, and locally a fair cover of native grasses and sedges. The land is arable and the surface relief favorable, but on account of the low fertility and excessive dryness at times, this soil has very little value for cultivated crops, and the pasture value is only fair.

Traunik loamy fine sand.—Traunik loamy fine sand is comparatively dry, is similar in appearance at the surface to Kalkaska loamy sand, but is distinguished from that soil by a rust-yellow, yellow, or gray mottled color at a depth ranging from 3 to 6 feet, indicating a higher average moisture content. The deeper underlying material is either sand or sand and gravel, but at a depth ranging from 5 to 15 feet the presence of a floor of limestone bedrock or clay prevents farther downward movement of water. Though limestone gravel may be present at a slight depth, the surface soil is apparently as strongly acid as that of the other sand soils.

The land is level or slightly undulating. Soils resembling the Granby, Saugatuck, and Longrie soils are included in a few of the lower lying areas.

The original forest growth consisted of sugar maple, elm, yellow birch, fir, spruce, and white cedar. The land is not excessively stony and is capable of producing fair yields of hay, potatoes, and small grain.

Blue Lake loamy sand.—Beneath the forest mold Blue Lake loamy sand is characterized by a lavender-gray leached sharp sand which extends to a depth ranging from 6 to 10 inches, where it is underlain by brown or umber-colored loamy sand or sandy loam. Most of the deeper underlying material is comparatively dry sand and gravel, but it contains occasional boulders and pockets or thin layers of red sandy clay. A noticeable quantity of limestone occurs in the underlying drift, although the soil proper is in general strongly acid.

This land is arable and is a little more productive than other soils in the group, because of the slightly loamier character of the brown subsurface layer and the presence of more clay and limestone at a slight depth. Only a small acreage occurs in Alger County, and none of the land is under cultivation. Fair crops of hay, oats, and potatoes have been produced on the same soil in other parts of the State.

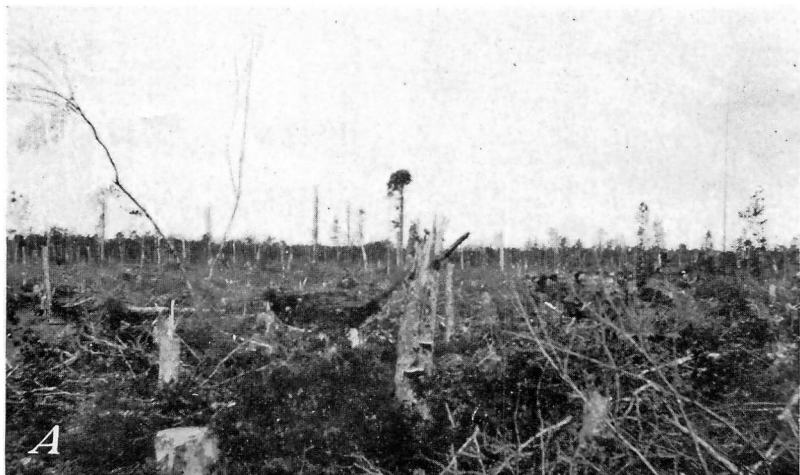
The original forest consisted principally of sugar maple, yellow birch, beech, elm, and hemlock. Most of the land has been cut over and is now occupied either by a second growth of the original species or by aspen and cherry in the more severely burned-over land. The more open land supports a good cover of grasses and weeds, which afford fair pasture.

SANDY LOAMS AND SANDS OF THE HARDWOOD AND PINE HILLS

All the sandy soils of the more hilly parts of the county have the same general soil profile. They are characterized by gray leached sand beneath the duff of the forest floor and by brown or yellow sand or sandy loam at a slight depth. In the surface layers, these soils are comparatively dry, incoherent, deep, penetrable, low in humus, and strongly acid. They are not highly productive, but in general are a little more productive than, and not quite so deficient in moisture as, the plains sands; but because of such characteristics as hilly surface relief, the presence of stones, the complexity of association with other soils, and location, they are considered as second- and third-class land from the point of view of present agricultural use.

A number of distinctions are made on the basis of textural differences, of color differences in the underlying sands or sandy clays, and the amount of limestone in the underlying parent material. The soils included in this group are Hiawatha loamy sand, Hiawatha fine sandy loam, Hiawatha sandy loam, Emmet loamy sand, Emmet sandy loam, Wallace fine sand, Bohemian fine sandy loam, Strong's loamy sand, and Strong's fine sandy loam.

The principal hilly areas occur in the central part of the county southwest of Munising, in the southeastern part bordering Delta and Schoolcraft Counties, and in the eastern part south of Grand Marais and on the border of Luce County.



A, Aspect of land immediately following lumbering. The original forest was mainly maple, beech, birch, and hemlock, a characteristic growth on the Munising and Onota soils. *B*, Dry sand-plain remnant of original red (Norway) pine forest on Rubicon sand.

Hiawatha loamy sand.—Hiawatha loamy sand comprises soil on the higher and more strongly rolling and hilly hardwood land. The deeper underlying material consists mainly of sand, but in a few places pockets of gravel and boulders and layers of clay occur at a slight depth, within reach of plant roots. To a depth ranging from 3 to 4 feet the soil is less uniform than Strong's loamy sand, from which it differs otherwise only in surface relief. The loose incoherent character of the soil, its strong acidity, lack of humus, and the hilly relief or strong slopes are depreciating factors, and none of the land is in agricultural use. It is, however, capable of producing fair forest growth. The virgin forest consists of a fairly dense stand of sugar maple, beech, and yellow birch, with a variable amount of hemlock and fir. The cut-over land is occupied by a second growth of the original species or, where more severely burned, by aspen, cherry, white birch, grasses, and briers.

Hiawatha fine sandy loam.—Hiawatha fine sandy loam is distinguished from Hiawatha loamy sand by a slightly finer texture and loamier feel in the surface soil layers and by the presence of layers or pockets of pale-red clayey sand or friable sandy clay at a depth ranging from 2 to 4 feet. The slopes are smooth and not excessively steep or stony, although scattered boulders are present. This soil holds more moisture and is probably more productive than the sands. However, since the soil in the areas shown on the map is not uniform and since the soil having clay close to the surface occurs only in small bodies, the land has but small prospective value for agricultural use. The original forest cover consisted mainly of sugar maple, beech, yellow birch, and hemlock, with a small proportion of elm and basswood. A few patches of virgin forest remain, but most of the land is in slashings and second growth or, where more severely burned, is covered with grasses, weeds, and briers. The more open land should have a fair value for grazing.

Hiawatha sandy loam.—The areas indicated on the soil map as Hiawatha sandy loam consist of small bodies of several distinct soils intimately associated. Deep sand, sandy loam, sandy clay, and gravelly and stony soils are so mixed that it is impractical to make separations on a small-scale map. Most of the soils are sandy loams, mainly of the Hiawatha, Munising, and Trenary series.

Areas classed as Hiawatha sandy loam lie in the vicinity of Munising and Wetmore on the hills and benches, from 150 to 300 feet above Lake Superior. The slopes range from smooth and gentle to excessively steep and from stone-free to moderately stony. The smoother land is capable of producing fair yields of the staple crops—hay, oats, barley, and potatoes. Crops in a single field may vary considerably, because the various soils range from highly acid to limy and from deep loose sand to compact cemented gritty clay. Most of the cleared land was originally covered with hardwood forest, and a part of the more hilly land enclosing South Bay remains in virgin forest.

Bohemian fine sandy loam.—Bohemian fine sandy loam comprises fine-textured sandy soils occurring in the valleys of the hilly upland. The surface layer to a depth ranging from 10 to 15 inches is fine sandy loam or even silty material, gray above and brown below,

and the underlying material is sand or sand and gravel, resting either on sandy clay or interbedded silt, fine sand, and clay at a depth ranging from 2 to 6 feet. This soil holds a little higher amount of moisture and is a little more productive than the plains and other valley soils, such as the Grayling, Kalkaska, and Au Train soils, although it has not yet been used for agriculture. The land is hummocky, and the soil is variable in content of sand and gravel and depth to clay, owing both to natural causes and to disturbance of the surface soil resulting from lumbering operations. The areas shown on the soil map comprise a complex mixture with Bohemian fine sandy loam predominating but with other soils, the same as, or very similar to, the Kalkaska, Munising, and Hiawatha soils associated. The original forest consisted mainly of maple, beech, yellow birch, and hemlock, and white pine was locally abundant. The land has been cut over and now supports a poor second growth including aspen, cherry, white birch, and service berry, with a fair grass cover in places where the brush and tree growth is scant.

Strong's loamy sand.—Strong's loamy sand occupies comparatively high upland areas. When viewed from a distance, the skyline appears even and the land planate, although locally there are pot-hole depressions and valleys, and the surface relief in reality is uneven or broken. The principal difference between this soil and the sandy soils of the lower lying drier hardwood and pine plains is the presence of layers of sandy clay and silt, together with pockets of gravel and boulders, in the underlying drift. In most places the surface soil is loose medium and fine sand to a depth of more than 3 feet, with very little or no limestone in the soil material.

The original forest growth consisted mainly of sugar maple, beech, yellow birch, and hemlock, together with a few elm, basswood, white pine, fir, and other species. Some of the land remains in virgin forest, and the rest is slashing or, where burned over destructively, has grown up to aspen, pin cherry, oaks, and sumac, with a fair grass cover.

None of the land is farmed, but it is arable and, if manured and fertilized, is capable of producing fair yields of the staple crops of this section. Its chief deficiency is low moisture content. The land is probably better suited to the production of trees than to cultivated farm crops.

Strong's fine sandy loam.—Strong's fine sandy loam is distinguished from Strong's loamy sand because of a slightly finer texture and loamier feel in the surface layers and the presence of layers or pockets of pale-red clayey sand or silt at a depth ranging from 2 to 4 feet. The slopes are smooth and not excessively steep or stony, although scattered boulders are present. This soil holds more moisture and is probably more productive than Strong's loamy sand, as evidenced by the quantity and kind of plant growth. However, since the soil in the areas shown on the map is not uniform and since the soil having clay close to the surface occurs only in small bodies, the land has little prospective value for agriculture. The original forest consisted mainly of sugar maple, beech, yellow birch, and hemlock, with a small proportion of elm and basswood. A few patches of virgin forest remain, but most of the land is in slashing

and second-growth trees, or, where more severely burned, is covered with shrubs, sprouts, grasses, weeds, and briars. The more open land has fair value for grazing.

Wallace fine sand.—Wallace fine sand comprises dry soil on low hills and dunelike ridges, both on the swampy plains and on the higher upland. This soil is distinguished from other hilly sandy soils by a very thick development of a brown or yellow slightly cemented layer just beneath the light-gray fine sand surface soil and by the greater thickness, uniformity in texture, and freedom from gravel and stones of the underlying sand. The soil is strongly acid to a depth ranging from 4 to more than 5 feet, is low in fertility, and is loose and incoherent both at the surface and underneath the brown or yellow cemented layer. The texture ranges from uniform fine sand to uniform medium sand.

The land has very little agricultural value, because of the small size of the separate bodies, its manner of occurrence, and its tendency to blow where vegetation has been removed. The original forest cover consisted mainly of white pine and red (Norway) pine, with a few mixed trees characteristic of the associated soils, either hardwoods or spruce, fir, and tamarack. The present growth consists of aspen, cherry, and red maple, with a few pine, and a ground cover of bracken, sweetfern, wintergreen, and blueberry.

Emmet loamy sand.—Emmet loamy sand consists of loose yellow deep sand soil occupying rolling and hilly areas which originally supported nearly pure stands of hardwoods. The soil is very similar to Hiawatha loamy sand, but it is distinguished from that soil because of a slightly higher amount of lime in the underlying material. The surface soil, however, in most places is strongly acid and does not appear to be materially different from other sand soils of the hills. None of the land is in agricultural use, and most of it has been denuded of the original forest cover.

Emmet sandy loam.—Emmet sandy loam has a gray sandy loam surface soil, a brown sandy loam subsoil, and is underlain at a depth ranging from 2 to 4 feet by pale-red clayey sand or sandy clay, which shows some evidence of being moderately limy. The moisture content is slightly higher than in Emmet loamy sand, and the tree growth indicates a little greater productivity.

STONY LOAMS AND SANDY SOILS OF THE PLATEAU UPLAND AND ROCK BENCHES

The high plateau upland and benches, or terrace plains, which are underlain by sandstone and limestone bedrock, constitute a distinct natural or physiographic division and also possess distinctive soil conditions. The highland bordering Lake Superior rises abruptly, either in perpendicular cliffs ranging from 200 to 300 feet in height, as at the Pictured Rocks northeast of Munising and on the northwest side of Grand Island, or by a succession of benches. Bedrock of white and red sandstones, and, farther inland, of limestone, is present at a slight depth, and it outcrops in the gorges and in the deep sharp valleys of streams which dissect the highland. The dissected tableland and rock benches occupy most of Onota Township in the northwestern part of the county, extending southeastward to Chatham; the highland along Lake Superior between Munising and Au Train;

and the highland back from the Pictured Rocks northeast of Munising.

The soils of this group are distinguished by the slight depth to bedrock and are, for the most part, extremely stony. The group includes two contrasting subgroups: one in which the soils are distinguished by the red color of the underlying soil or drift and a highly acid condition, and the other in which the soils are distinguished by a brown color and a calcareous underlying soil or drift. The soils range in texture from sands to loams, the greater part being stony loams or moderately heavy fine sandy loams and medium sandy loams. In all these soils the usual brown or yellow coloration just beneath the forest mold and gray ashy leached layer is so strongly developed in places that it gives color and structure to the plow soil. The fertility of the soils ranges from medium to high, but on account of extreme stoniness or slight depth to bedrock, most of the land is not used for agriculture. Locally the land is marked by short abrupt slopes or scarps and by deep sharply cut valleys or gorges, but the larger part is level or gently rolling.

The soils in this group include **Munising loam**, **Munising loam**, poorly drained phase, **Munising sandy loam**, **Onota stony fine sandy loam**, **Chatham stony loam**, and **Longrie loam**.

Munising loam.—Munising loam is characterized by a red clayey sand or sandy clay layer which becomes very compact and cemented on exposure and has, therefore, somewhat the character of a hardpan. The covering of gray or brown sandy loam or loam over this clay ranges in thickness from 1 to 2 feet. In most places both the surface soil and the underlying sandy clay are strongly acid. A number of variations of the soil occur, depending on the texture of the surface layer, which may be sandy loam, fine sandy loam, or loam, the depth to sandstone bedrock, and the relative abundance of stones. Where the slopes are not excessively steep and on the less stony areas, the land is capable of producing fair yields of the staple crops—hay, oats, barley, and potatoes—as it holds moisture fairly well and is moderately fertile. The wet areas and more stony land have very little agricultural value. The deeper and better drained land was covered originally by a forest of maple, beech, yellow birch, and hemlock; and on the flatter land, where the bedrock lies closer to the surface and where a more compact clay subsoil and a moister condition exist, there was a larger proportion of balsam fir, spruce, cedar, and white pine. A small percentage of the land on the mainland remains in virgin forest, and practically all the forest on Grand Island is virgin. Some of the cut-over land is very recent slashing, but the older cut-over land, where it has escaped destructive burning, supports a fair second growth of the original species. The grass cover, which is excellent, furnishes good grazing in places where the brush and trees have been kept out by fires.

In the management of this soil, removal of stones is necessary, following which good tilth and seed beds can be obtained. The soil is too acid for successful growing of alfalfa and sweetclover, but it produces a good stand of timothy and alsike. The addition of organic matter is essential. In the flatter land, where bedrock lies close to the surface, an excess of water may be held in the spring.

Munising loam, poorly drained phase.—The poorly drained phase of Munising loam differs from typical Munising loam chiefly in

having a higher average moisture content throughout, a thicker and more prominent leached wet gray layer just above the cemented sandy till, and bedrock or impervious till closer to the surface. Such areas occur generally on flats, in slight depressions, and on seepy slopes. Most of the land has been cut over and is in second-growth timber, with good grass on the more open spots. The original forest included a higher proportion of balsam fir, spruce, white cedar, and white pine than the typical forests on the better drained areas of Munising loam. Very little of this poorly drained land is under cultivation.

Munising sandy loam.—Munising sandy loam is closely related to Munising loam, both in soil characteristics and in geographic occurrence. It consists of a covering of loose sandy loam or loamy sand, from 1 to 2 feet thick, over red hard dense sandy clay till. The sandy surface soil where cultivated is grayish brown, and where recently cleared a field may have a spotted appearance, with small areas of gray sandy loam alternating with brown or grayish-brown areas. The virgin soil has three rather distinct soil layers developed in the sandy material above the red sandy clay: (1) Light-gray leached acid sand, 6 or 8 inches thick; (2) dark-brown loamy sand or sandy loam, acid in reaction, 12 or 15 inches thick; and (3) gray or slightly reddish gray bleached weakly cemented sandy loam which is acid in reaction and 6 or 8 inches thick. Where not destroyed by fire, the topmost surface-soil material consists of loose brown forest litter, leaf mold, and sandy humous soil.

The original and present vegetation, and the extent and possibilities for utilization of this soil are similar to those of Munising loam.

Onota stony fine sandy loam.—Onota stony fine sandy loam comprises thin stony sandy soil overlying sandstone bedrock. In places the soil consists simply of a mass of slabs of red and gray sandstone and boulders, with the spaces filled with red clayey sand, resting on bedrock at a depth ranging from 2 to 6 feet; and in other places a thin layer of reddish-gray sandy loam or clayey sand, which is compact and mottled more or less with rust yellow and gray, occurs over the bedrock.

This soil is low in lime and is acid throughout, but it contains sufficient moisture and fertility to support a dense stand and large volume of tree growth. The principal factors which depreciate its agricultural value are the extreme stoniness and the slight depth to bedrock, so that only a few spots, which approach the Munising soils in character, can be utilized for field crops under present economic conditions. With the exception of the short slopes or scarps, separating one level bench or tableland from another, and the sides of the gorgelike valleys of streams flowing into Lake Superior, the land is comparatively level, although low mounds a few feet high and a pitted surface, caused by the uprooting of trees, cause local irregularities.

Included with areas of Onota stony fine sandy loam is a considerable aggregate of wet land which, to a depth ranging from a few inches to a foot, consists of moss or peaty duff overlying red or white sandstone, with or without a rust-colored or brown hardpan of sand intervening. Small areas of extremely cobbly dry soils similar to, or identical with, the Waiska soils also occur.

On the areas of deeper soil, the original forest consisted predominantly of sugar maple, beech, yellow birch, and hemlock; and on the areas of wetter soil there was a dense growth of fir, cedar, spruce, hemlock, and white pine, together with a smaller percentage of yellow birch, white birch, maple, ash, and elm. Stones and bedrock interfere with the downward penetration and free development of tree roots. Rather large tracts of virgin forest remain, but most of the land, especially on the mainland, has been cut over and is either recent slashing or is occupied by a fair second growth of the original species. The grazing value of this land is poor, except where trees and brush have been killed by fire or by clearing. None of the land is in agricultural use.

Chatham stony loam.—Chatham stony loam is underlain by a coarse deposit consisting of boulders and gray or pale reddish-gray sand and gravel. Bedrock, either limestone or sandstone, is generally present at a depth ranging from 4 to 12 feet, but in some places a thin bed of stony clayey drift may intervene. This soil is distinguished by the high percentage of glauconitic calcareous sandstone or limestone and by the presence of a brown or umber-colored loamy layer which lies at a depth of a few inches below the surface and extends to a depth ranging from 15 to 30 inches. This sub-surface layer is plowed up when the soil is cultivated, thereby imparting loaminess and light-brown, or in places a rich dark-brown, color to the cultivated surface soil. The soil is well supplied with lime, holds sufficient moisture to produce crops, and otherwise appears to be fairly fertile, and it presents no especial tillage difficulties after the stones and stumps are removed. Excellent yields of oats, barley, hay, alfalfa, and potatoes have been obtained on this soil at the Upper Peninsula Agricultural Experiment Station at Chatham.

The surface relief is comparatively level but is characterized by short abrupt scarp-like slopes occurring in a few places. The chief drawback in the utilization of this soil is its extreme stoniness.

The virgin forest consisted of a dense stand of hardwoods, chiefly sugar maple, beech, elm, basswood, and yellow birch, with which some fir, cedar, and hemlock were associated. Stumps are very numerous on cut-over land, and their removal is a considerable factor in the cost of preparing the land for agricultural use. Stump land, kept clear of trees and brush, supports an excellent cover of both introduced and native grasses and provides good pasture for either sheep or cattle.

Longrie loam.—Longrie loam is underlain at a depth ranging from 1 to 4 feet by limestone bedrock. The material from which the soil is derived is either sand or a coarse mass of sand, gravel, and stones. In the shallower better drained places, the limy material is weathered, resulting in a small amount of clay, sufficient to produce a brown or yellow loam throughout its whole thickness. The soil is fairly well supplied with humus, is nearly neutral or alkaline in reaction, and is fairly fertile. The chief depreciating factors affecting the value of the land are stoniness, slight depth to bedrock, and locally poor underdrainage. In places water is held on the flat rock floor or in pits formed by the crumpling of rock strata and unequal corrosion by the ice sheets which passed over this region. In the

wetter situations, a thin layer of muck has accumulated on the surface, and the underlying material next to the bedrock is a yellow or olive-colored wet slightly sticky mass of sand, gravel, and stones. These areas represent a separate soil type, but owing to their small extent in Alger County, it is impractical to separate them on a small-scale map.

Longrie loam occupies narrow rock benches and small bodies of tableland. The surface relief is level but is characterized by short abrupt scarp slopes. The original forest consisted of sugar maple, beech, elm, basswood, and yellow birch on the typical soil and of cedar, fir, hemlock, white pine, elm, and ash on the wetter land.

Some of this land on the Upper Peninsula Agricultural Experiment Station farm at Chatham has been cleared and has produced good yields of hay, oats, barley, sunflowers, and rutabagas. Where cleared of trees and brush, the soil supports a good grass cover which affords excellent pasture.

LAKE-SHORE SOILS

The shore of Lake Superior is bordered by a wave-washed barren strand, by beach ridges and dunes, together with both low-lying and high-lying lake-bed plains and rock benches. Most of the soils are sandy, gravelly, and stony. The land is in part excessively dry and in part wet, the latter areas being either marshy or swampy. These soils, in general, have very little agricultural value, although climatic conditions are more favorable here and the growing season is longer than in the interior. A few small bodies of fairly fertile and productive loam soil occur on the lake-shore benches in the vicinity of Grand Marais, but elsewhere the land is poor because of an association of poor wet and dry sands and peats in small bodies, because of stony soils, and because of shifting of sand dunes by the wind.

The soils of this group include Deer Park fine sand, Sauble fine sand, Alger loam, Waiska gravelly sandy loam, Shell Drake sand, and coastal beach. In places where cliffs appear along the lake, the soils of the bordering highland are mainly Onota and Munising soils, which have been described under other headings.

Deer Park fine sand.—Deer Park fine sand is the name applied to the soil of the old stable dunes which are composed of gray or yellow sand. The sand is mostly of medium texture, is colored gray by organic matter to a depth ranging from 2 to 8 inches, and the underlying sand is yellow to a depth ranging from 1 to 3 feet. The sand is not appreciably cemented and is so loose that it is likely to shift or "blow out" where the cover of vegetation is broken. The surface relief is characteristic of dunes, or wind-blown sand. It is characterized by knolls or ridges and complementary depressions or valleys.

The principal area lies directly east of Grand Marais. The land originally supported a fair growth of red (Norway) and white pine, and the present tree growth consists of a few red and white pines, together with patches of jack pine, red oak, aspen, and white birch. Blueberries, sweetfern, bracken, reindeer moss, and wild oats, or buffalo grass, are common.

The land has no agricultural value, but it is capable of supporting a variety of native plants and hence may have value for recreational purposes, at the same time providing a small amount of pasture and feed for wild life.

A few small isolated dunes in the interior of the county are also mapped as Deer Park fine sand. These are old stable dunes completely covered with vegetation, and they originally supported forests of red pine and white pine. Here the soil differs from that of the sandy hill land, in that it is looser and more uniform to greater depth.

Sauble fine sand.—Sauble fine sand is the name applied to the soil of the dunes directly west of Grand Marais. Here the sand has a salmon or faint-red color. The dunes for the most part are stable and covered with vegetation, but in places they are being shifted by the wind and present a desolate, barren aspect. The sand is slowly moving inland, burying the hardwood forest of the adjacent older land surface and obstructing drainage. The dunes occupy a strip of land about 4 miles long, reach a maximum width of a little more than a mile, and rise to a maximum height of 200 feet above Lake Superior. The sand is rather uniformly of fine and medium texture. It becomes excessively dry at the surface, but remains surprisingly moist at a slight depth. The land has no agricultural value because of the unfavorable surface relief and the looseness of the sand. It supports a varied vegetation, including beech, maple, birch, hemlock, white pine, red (Norway) pine, jack pine, spruce, cedar, and aspen, together with the characteristic shrubs and herbaceous vegetation of the shifting beach sands and dry pine plains, such as wild-rye, sea sandreed, beach pea, wormwood, blueberry, bracken, wintergreen, and reindeer moss.

Alger loam.—Alger loam consists of light-brown loam, composed of uniform very fine sand, silt, and fine sand, ranging in thickness from 1 to 4 feet. It occurs as a mantle over old buried soils of the same texture as the present soil or over coarse sand and gravel. Bedrock is present in a few places at a depth ranging from 3 to 10 feet. A peculiarity of this soil is that very little change in color and texture takes place to a depth ranging from 1 to 4 feet and that organic matter is distributed throughout without any especial accumulation on the surface. The soil material appears to consist of a thin mantle of dust blown from the dunes to the north and west. The land is smooth or gently undulating, is not excessively dry or subject to blowing, and is easily tilled. The soil is nearly neutral, or not highly acid, and is fairly fertile. The land originally supported a hardwood forest of sugar maple, beech, yellow birch, and hemlock. Most of the land has been cleared, and that part under cultivation is producing fair yields of potatoes, hay, and oats. The climatic conditions are favorable for the production of fruit and garden vegetables for home use and local markets.

Waiska gravelly sandy loam.—Waiska gravelly sandy loam is a dry soil consisting mainly of an unconsolidated mass of cobbles, boulders, gravel, and sand. A very thin surface covering of forest litter and duff, an inch or two thick, is underlain by gray, brown, or red loam or sandy loam filling the interstices between the stones to a depth ranging from 5 to 12 inches. Little or no limestone mate-

rial is in the coarse matter, and the mineral soil is strongly acid in reaction. This soil occurs as low, narrow, dry ridges and gentle swells representing old beach deposits and ice-deposited ridges. In a few places the deposits are between 3 and 4 feet thick and rest on sandstone bedrock.

The original forest consisted mainly of sugar maple, yellow birch, beech, white pine, and red (Norway) pine, together with balsam fir and spruce, especially where adjacent to wet land. The present growth consists mainly of aspen, white birch, and remnants of the original forest.

The aggregate acreage of this soil is small, and the land has very little or no agricultural value on account of its extreme stoniness and manner of occurrence, although the tree growth indicates fair fertility.

Sheldrake sand.—Sheldrake sand occurs as low ridges and level strips of beach and lake-bed sand lying directly along the shore of Lake Superior. The sand is of gray or faint-salmon color, incoherent, and medium or coarse in texture. It is of recent deposition and shows very little change from its original condition, other than a coloring in the surface layer, to a depth ranging from 2 to 4 inches, caused by the accumulation of organic matter from the plants growing on it since its deposition. Some included areas of wet sand occur in depressions, in which the sand is water-soaked and stained a dirty gray or smoke color.

Sheldrake sand is strongly acid—practically free from limestone influence—and in this respect differs from Eastport sand, which represents similar recent sand soils along the shores of Lake Michigan and Lake Huron.

Sheldrake sand is of small extent and has practically no agricultural value. It possesses sufficient moisture and fertility, however, to support a fair growth of natural vegetation. On most of the land, the original tree growth apparently was fairly dense and consisted mainly of conifers, including some white pine and red pine. The present growth includes white birch and aspen, together with some balsam fir, spruce, and a few red oaks. In places where the surface soil is shifting under wind action or is covered by recent wind-blown sand, a growth of beach grasses, such as wild-rye, long-leaved reed-grass, and sea sandreed, occurs. Such plants as tall wormwood, beach pea, blueberry, wintergreen, and bearberry are also common.

Coastal beach.—Coastal beach comprises recently uncovered lake bed, together with the strand or wave-washed beach, along the shore of Lake Superior. The texture is mainly medium or coarse sand, but in places the material is gravel, cobbles, or sandstone bedrock.

This land consists of narrow sloping marginal strips, for the most part ranging from 50 to 100 feet in width. Most of the land is bare of vegetation, other than a thin or scattered growth of sedges and rushes.

SANDY AND CLAY SOILS OF THE SWAMPS AND WET LAND

Wet sandy soils occupy narrow strips on the borders of peat swamps and lakes and also occupy larger bodies of flat land where the water table is held up by underlying clay or bedrock. Drainage conditions range widely, so that some of the land included in

this group is nearly as permanently wet as the peat swamps, and in other places, where the height of the water table fluctuates, the surface may become dry and evidence of permanent water-logging appears only at a depth ranging from 2 to 3 feet. In these latter situations peculiar rust-colored or brownish-black layers of sand, or sandy hardpan, develop at a slight depth. The soils have a black mucky or peaty surface layer which is directly underlain by a gray or almost white bleached or leached layer.

This kind of land has little agricultural value, as the natural fertility, durability, and size of the separate bodies are not sufficient to justify the high cost of reclamation, which would be great, owing to poor drainage, dense cover of vegetation, and the presence of stumps that must be removed.

Under natural conditions this land supports a dense plant growth as a result of the combination of abundant moisture and a thick surface layer of mucky or humous soil. Wet land directly underlain by clay occurs in small bodies. Such land in general includes a higher percentage of hardwoods in the original forest, and when cleared of trees it affords better pasture and offers greater possibilities for agricultural use than the wet sands.

The soils included in this group are Newton sand, Munuscong fine sandy loam, Saugatuck sand, Ogemaw fine sandy loam, Ontonagon clay loam, Brimley fine sandy loam, and Burt loam.

Newton sand.—Newton sand comprises the soil of the wetter swamps, in which the water table is but slightly lower than that of the peat swamps.

The soil is characterized by a thin peaty covering, ranging from 2 to 8 inches in thickness, over gray water-soaked sand which in most places shows a smoke-colored stain or rust-yellow splotching. Most of the sand is medium in texture, and in most places it extends to a depth of more than 3 feet, although in some places, particularly in the northwestern part of the county in association with the Onota soils, bedrock of sandstone is present at a slight depth beneath the water-soaked sand and gravel. The water table generally lies at a depth of 12 or 15 inches, and at times it is practically at the surface.

This soil is widely distributed and occurs in part on wide flats but mainly in small bodies as narrow strips bordering swamps and lakes; it also occurs in depressions between sand ridges on the low-lying sandy plain bordering the shore of Lake Superior. Some of the soil included with mapped areas of Newton sand is little else than shallow peat of the Riffe or Greenwood type, and in other places it represents a transition into Saugatuck sand.

Newton sand is strongly acid, and, aside from the surface layer of organic matter, it is leached water-logged sand, and the fertility is low. It is not used for cultivated crops and under present economic conditions has practically no agricultural value.

Most of this land is covered by a dense thicketlike growth of aspen, alder, willow, white birch, black spruce, cedar, and tamarack, together with blueberry and shrubs common to the peats and mucks. Originally it supported considerable white pine. Vegetation is very shallow rooted, on account of the high water table.

Munuscong fine sandy loam.—Munuscong fine sandy loam is a soil which, like Newton sand, occupies a drainage situation but slightly above the level of the peat and muck swamps, but it differs from

Newton sand in being less strongly acid and presumably higher in lime, as it is associated with the limestone bedrock and the more limy drift.

This soil consists of a thin mucky covering, ranging from 2 to 10 inches in thickness, over gray water-soaked loamy fine sand. The sand is in general fine or medium in texture, and it is underlain by sandy clay at a depth ranging from 24 to 36 inches, although in places it extends to a depth of more than 3 feet. In such places the soil is generally a little lighter in texture and a little less fertile. In other places a rather large quantity of gravel and stone, a part of which is limestone, occurs.

This soil occurs in both small and fairly large bodies, mainly in the southwestern part of the county, in association with limestone drift. It has practically no agricultural value because of poor drainage, expense of removing stumps and roots, small size of bodies, association with other poor soils, and location, but it is capable of producing good pasture when cleared of trees and brush. Practically all the land has been cut over or culled, and it is now characterized by a dense junglelike growth of white cedar, balsam fir, spruce, aspen, tamarack, alder, willow, and white birch, together with some elm, ash, red maple, and balm-of-Gilead poplar. It is sufficiently fertile to produce a dense growth and large volume of trees.

Saugatuck sand.—Saugatuck sand comprises the wet sandy soil with gray sandy surface soil and a characteristic subsoil, or hardpan layer, of rust-colored or brownish-black sand. The water table fluctuates from a depth of a few inches to 3 feet below the surface, and the sand in most places is 3 feet or more thick. Most of the land is flat and lies at an elevation ranging from only 1 to 5 feet above the adjacent swamp or water surface. The surface relief is in general uneven, owing to a pit-and-mound condition, especially on old cut-over land. Although the sandy hardpan and water-logged condition are characteristic, they are not everywhere present in the areas as shown on the soil map, since slight differences of a few feet in elevation cause either a wetter or drier condition, and in many places Newton, Ogemaw, or Rubicon soils are intimately associated.

Saugatuck sand is strongly acid, and its fertility and productivity are low. Under natural conditions the soil supported a fairly heavy volume of vegetation. Large white pine and hemlock grew on the higher land and a mixture of balsam fir, cedar, spruce, aspen, red maple, elm, birch, and ash on the wetter associated soil.

Ogemaw fine sandy loam.—Ogemaw fine sandy loam is the name applied to the soil on the wet land, which is characterized by a thin cover of fine sand or fine sandy loam, overlying comparatively impervious limy clay. The sandy layer is water-logged at the point of contact with the underlying clay, but the average height of the water table, or upper limit of complete saturation of the ground, is less than that of the more swampy sandy soils, such as the Newton and Munuscong. The surface color is dark gray from an accumulation of organic matter, and a definitely rust-colored or brown sand is present at a slight depth.

In the southwestern part of the county, in association with the Trenary soils, the sand and underlying clay are coarser than in

the small areas on the red-clay bench land along United States Highway No. 28 east of Munising Junction.

Ogemaw fine sandy loam is of comparatively little importance because of the small size of the separate areas. The land, however, is moderately productive and can be utilized for pasture where cleared of trees and brush. It will produce good yields of hay and small grains if provided with adequate drainage.

Ontonagon clay loam.—Ontonagon clay loam includes the land underlain by red plastic stone-free clay and silt. The soil where undisturbed consists of a surface layer of moist black silty loam underlain by gray silt or mottled clay. A high percentage of water is held, because of the impervious character of this clay, so that the soil is wet and cold. A few separate bodies, only a few acres in extent, occur on the red clay bench land, or old lake-bed plain, southwest of Munising. Part of the land is level or flat and partly covered by a thin veneer of fine sand, and a part is on slopes where the red clay is exposed by erosion.

This soil is productive, but it occurs in such small bodies that it is of comparatively little importance. It originally supported, in association with Ogemaw fine sandy loam, a dense stand of a mixed forest growth consisting mainly of white pine, balsam fir, elm, ash, basswood, maple, and aspen. Its only use at present is for hay and pasture.

Brimley fine sandy loam.—Brimley fine sandy loam occurs as flat or gently sloping land which is wet but not so permanently swampy as the peat and muck swamps.

In Alger County this soil for the most part shows the following profile: (1) Forest litter and humous soil, 2 or 3 inches thick; (2) gray and pale-lavender leached fine sand, from 2 to 10 inches thick; (3) yellow or dark-brown fine sand, in places slightly cemented, from 3 to 15 inches thick; (4) wet yellow or gray, splotched with rust color, fine sand grading into pale-red interstratified silt and clay. The top layers are strongly acid, but the underlying silt and clay are generally calcareous at a depth ranging from 3 to 5 feet.

This soil occurs in small bodies in the eastern part of the county south of Grand Marais. The land originally supported a thrifty forest including a mixture of white pine, balsam fir, white spruce, and hemlock, with which were intermingled yellow birch, elm, ash, basswood, and sugar maple. The present growth on old cut-over land consists chiefly of aspen, but in places a fair stand of the original species has been reproduced.

This soil is not utilized for cultivated crops because of the small size of the separate bodies, occurring in association with swamps and other poor land, and because of unfavorable location. When properly handled, it is probably capable of producing fair yields of timothy and alsike hay, oats, wheat, field peas, and potatoes. The soil is free of stones and gravel, and is easily tilled. This land should also afford fair pasture, as it produces alsike and timothy in addition to native grasses in places where the brush and tree growth is not too thick.

Burt loam.—Burt loam comprises the wet black loam soil on the benches directly south of Grand Marais. The surface soil is peculiar, in that it is composed of black and gray stone-free silt and very fine sand, which appear to consist of dust blown from the dunes

and beach of Lake Superior directly to the north and west. In most places water-logged sand and gravel or clay are present at a depth ranging from 1 to 2 feet, and in places brown or rust-colored sand or hardpan is present. Sandstone bedrock, which occurs at a depth ranging from 1 to 8 feet, forms the nearly level floors of the benches or terraces and causes the poor drainage condition. This soil is fairly fertile, but because of the small size of the areas and difficulty of effecting drainage it has been used very little for agriculture. If cleared of trees, it will furnish excellent pasture and when drained can be used for gardens and general farm crops.

STREAM-BOTTOM SOILS

The stream-bottom, or alluvial, soils occupy only a very small acreage. All the streams in the county are small. Those flowing northward into Lake Superior are either very short or have cut deep gorgelike valleys, and those flowing southward are sluggish, originate in or flow through peat swamps, and, therefore, have no true alluvial valleys. Ewen loam and Griffin loamy fine sand are included in this group.

Ewen loam.—Ewen loam is mapped where alluvium has been deposited in bottoms which have been well drained. In most places it is uniformly composed of sandy loam or loam, is brown or faint red in color at the surface, and contains considerable organic matter throughout.

Griffin loamy fine sand.—Where the alluvial deposits are mottled gray and rust brown, are sandy in texture, and are water-logged within a few inches of the surface, the soil is mapped as Griffin loamy fine sand. This soil is fertile, but, because of poor drainage and narrowness of the bottoms, the land has no agricultural value. The tree growth is taller and larger than that of the peat swamps, and the forest contains a high proportion of elm, ash, soft maple, balm-of-Gilead poplar, and aspen, in addition to white pine, hemlock, cedar, and balsam fir.

ORGANIC SOILS

Organic soils are composed dominantly of plant matter and in this respect constitute a distinct class as compared with the more common inorganic soils, which are composed dominantly of mineral matter. In this county organic soils occur in forested swamps, open heath bogs, and marshes. The deposits are composed of the remains of plants which have grown in successive stages upon a particular site. They have accumulated in permanently wet situations, such as flat plains or valleys underlain at a slight depth by clay or bedrock; slopes permanently wet from seeping springs; and certain types of lakes in which the water is comparatively calm and the water level is not subject to any considerable fluctuation. Organic soils of the flat plains and valleys predominate in acreage.

The deposits considered as soils differ in stratigraphy, or succession of different layers, in texture, structure, thickness, depth of water table, age, movement of water, degree of decomposition of plant remains, and chemical characteristics; but on account of the great amount of time and labor involved and the small economic

justification for a complete differentiation, no attempt has been made to delineate on the map all the subdivisions which it is possible to make in a soil classification. Seven fairly well defined types of organic soils are recognized although boundaries cannot be so accurately drawn as for the mineral soils. The aggregate area of all organic soils amounts to 19.1 percent of the total area of the county. This group includes Carbondale muck, Houghton muck, Kerston muck, Rifle peat, Spalding peat, Greenwood peat, and Tahquamenon peat.

As a class the organic soils are characterized by a low volume weight and low specific gravity, high water-holding capacity, high specific heat, and high shrinkage on drying. They are generally high in total nitrogen content, generally low in potash content, and extremely variable in lime and phosphorus content. The reaction generally ranges widely, from alkaline to very strongly acid, in the Michigan mucks and peats. Under cultivation, these soils undergo change from their virgin condition much more rapidly than do mineral soils. They are also peculiar as soil in that they are combustible, and when drained or very dry they are likely to be more or less completely burned. In cultivation the finely divided plowed soil is likely to be drifted by the wind.

Carbondale muck.—Carbondale muck comprises the dark-brown loamy or granular muck which is very high in organic-matter content and is alkaline, neutral, or slightly acid in reaction. The darker colored soil extends to a depth ranging from 1 to 2 feet, before the coarser brown or yellow less decomposed and more peaty material is reached, or to about the average depth of the water table. This soil represents the darkest and most productive type of muck land, although the alteration and decomposition of the peat parent material is nowhere so complete in the Upper Peninsula as in the southern part of the Southern Peninsula. As compared with Rifle peat, Spalding peat, and Greenwood peat, the movement of drainage water is freer, decomposition and disintegration of the plant matter is greater, the content of lime and the content of ash on ignition are higher, and the color is darker. Most of the deposits of Carbondale muck range from 1 to 10 feet in thickness. They are underlain by sandstone or limestone bedrock, by sand, or by clay, but marl is much less common than in the southern part of the State.

Most of the land of this kind is in swamp forest. The vegetation is characterized by a dense growth of arborvitæ, black spruce, balsam fir, and tamarack, but many elm, black ash, red maple, white birch, hemlock, white pine, and balm-of-Gilead poplar trees are, or were originally, intermingled. Individual trees reach a larger size and the total volume of growth is greater on Carbondale muck than on Rifle peat and Spalding peat. Where the trees have been cut for lumber or have been destroyed by fire, the second growth includes aspen, alder, and willows.

Carbondale muck comprises more than two-thirds of the total acreage of the organic soils in Alger County. It occurs mainly in association with the more clayey and calcareous drift soils and the Trenary soils in the southwestern part of the county, in irregular bodies where the land is flat and drainage is sufficiently retarded. It is widely distributed as long narrow strips in stream valleys, and in small bodies along the borders of lakes and on seepy slopes.

Practically none of this land is used for agriculture, other than a limited use of the stump land for pasture. Its chief value seems to be in the tree growth which it is capable of producing. This type of muck is suitable for truck and hay crops when properly prepared, but under present conditions extensive agricultural development does not seem to be warranted.

Houghton muck.—Houghton muck comprises dark-brown spongy or feltlike finely fibrous muck or peat. In general, a small amount of decomposition has taken place on account of the high water table, although typically the surface soil is dark colored to a depth of a foot or more, and in places the base of the peat deposit is a black or gray fine pasty mass. Houghton muck differs from the other organic soils in having a finer texture, and it is less strongly acid than Greenwood peat. The deposits are for the most part shallow and are underlain by sand.

The natural vegetation is composed chiefly of sedges and grasses. Therefore this type of organic material constitutes wet prairie rather than forest swamp or heath bog, although some dwarf willow, clumps of aspen and birch, and perhaps a few scattered black spruce grow in places.

None of the land is in agricultural use. As on the other organic soils, it is possible to grow cultivated crops, but because of unfavorable location and cost of reclamation, present agricultural development does not seem to be warranted.

Kerston muck.—Kerston muck lies directly along stream courses and consists of organic matter and alluvial mineral matter either admixed or in alternate layers. Most of the muck is nearly black or brown, either woody or fibrous, and nearly neutral or not highly acid in reaction. The water table in most places is high, and the land is swampy. In a few places, particularly on the banks of streams, mineral matter may predominate over organic matter. Most of the alluvium is sandy.

The tree growth is dense and junglelike, and it consists of cedar, spruce, tamarack, alder, aspen, willow, white birch, elm, ash, balm-of-Gilead poplar, and an occasional white pine.

The land has no value for agriculture, although the soil is comparatively fertile and is capable of producing a fairly large volume of growth of wild plants adapted to muck soils.

Rifle peat.—Rifle peat is dark-brown or brown coarsely granular or woody peat which in general is acid in reaction and contains very little admixed mineral matter. The more decomposed and disintegrated darker colored surface layer, which contains the remains of woody vegetation, is generally thin, ranging from about 4 to 8 inches in thickness. This layer is underlain by lighter brown coarser and less decomposed woody peat or by raw fibrous peat in the thicker deposits. In most of the deposits the average depth to the water table is probably not more than 1 foot. The peat deposits in general probably range from 8 to 10 feet in thickness, except in some places where they represent filled lakes and are deeper. The deposits are underlain by either clay or sand and in a very few places by marl.

The vegetation is characterized by a dense junglelike growth of arborvitae, black spruce, and tamarack, in which either the arborvitae or the tamarack may greatly predominate. Aspen, alder, wil-

low, and red-osier dogwood also grow in dense thickets. The value of the land lies in the tree growth it supports and as a cover and feeding ground for game.

Spalding peat.—Spalding peat represents a transitional soil from the open heath-bog type to the forested or swamp types of organic soils (Rifle peat and Carbondale muck).

The surface layer of Spalding peat is strongly acid, is either brown woody or spongy fibrous material, and is only slightly decomposed. Sphagnum moss is common as a surface mat. Shrubs, such as leatherleaf and Labrador-tea, and blueberries comprise the ground cover in association with the trees, chiefly black spruce and cedar.

Spalding peat is widely distributed on flat wet sand plains as extensive swamps and in smaller deeper bodies representing the sites of lakes. It occupies 12 percent of the total area of organic soils.

The land has little or no agricultural value. Its value lies chiefly in the tree growth which it is capable of producing and as a refuge for game.

Spalding peat is distributed throughout the county in about the same manner as Carbondale muck and Rifle peat. The water table is slightly closer to the surface, and decomposition has been less, or alteration has taken place to less depth. It has not everywhere been possible to make accurate and consistent separations, and much of the organic soil included with Carbondale muck, especially in the larger bodies, is more properly the intermediate Spalding and Rifle peats.

Greenwood peat.—Greenwood peat consists of brown or yellow fibrous coarse-textured nearly pure organic matter showing very little decomposition. The material is characteristically very strongly acid in reaction. The water table is normally at or within a few inches of the surface, although during very dry periods it may sink to a depth ranging from 2 to 3 feet. The deposits are variable in thickness, some of them being more than 30 feet deep.

Most of this type of peat occurs in heath bogs characterized by such plants as leatherleaf, Labrador-tea, blueberry, cranberry, and Sphagnum moss. Here the topsoil is composed of a feltlike or spongy mat of sedge roots and mosses. A stunted and open growth of black spruce may also occur.

Greenwood peat has accumulated mostly in lakes, but in part it represents shallow accumulations of organic material, ranging from 2 to 5 feet in thickness, on wet sandy flats.

The land has practically no value under present economic conditions, except perhaps for the wild blueberries and cranberries it yields and as a refuge for wild life.

Tahquamenon peat.—The areas mapped as Tahquamenon peat comprise water-covered land occupied by a thin or fairly dense cover of sedges, grasses, rushes, and cattails. The material is brown or gray finely fibrous or pasty peat which in most places is thin, ranging from 1 to 4 feet in thickness. The peat may be either acid or nearly neutral but is not so highly acid as Greenwood peat. The water table lies higher than in Greenwood peat, or the land is permanently water covered, so that the peat is less decomposed. The vegetation includes more purely aquatic plants than grow on Houghton muck.

The land has no present agricultural worth but may have some value as a refuge and feeding ground for wild life.

CLASSIFICATION AND ORIGIN OF THE SOILS OF ALGER COUNTY

The taxonomy, morphology, and evolution of the soils of Alger County are discussed in the following pages.

The dominant soils of the county are those which are almost entirely inorganic, disregarding any superficial accumulation of organic matter, and have a solum distinct from the underlying geologic formation. Such soils are estimated to comprise 79 percent of the total area of the county; organic soils, about 19 percent; unconsolidated geologic formations not appreciably altered by soil-forming processes and hard rock, barren, or with no appreciable covering of detrital matter, about 1 percent; and water surface, inland lakes, and streams, about 1 percent.

The mineral soils are represented by three major taxonomic divisions, based on the average amount of water in the solum, as follows: (1) Soils containing normal moisture for the region, in which the soils have developed under free drainage and aeration; (2) soils in which water is contained permanently to the point of soil saturation and water-logging; and (3) alternately wet and dry soils, in which periods of saturation to the surface are followed by periods of dryness. The first division is estimated as occupying about 85 percent of the total area of this class of soils; the second, including such soils as the Newton, about 10 percent; and the third, including soils like the Saugatuck, about 5 percent.

The well-drained mineral soils which have well-developed profiles belong to the podzol group, and those which do not show the typical podzol profile are at least podzolic in that leaching, particularly the removal of calcium and magnesium carbonates, is dominant in the soil-forming processes.

The generalized profile for the virgin soil in the division of normal moisture and order of mature soil (ektodynamorphs) shows the following layers: (1) Litter and forest mold or duff, (2) a very thin humous soil layer, (3) a highly leached gray layer, (4) a layer having brown or yellowish-brown humic and iron oxide coloring, (5) a layer of maximum clay content, maximum weathering, and maximum coloring from ferric oxides, and (6) the parent material and geologic substratum. Layer 5 is weakly developed but is typically present, and the soils probably differ from podzols in some other regions where layer 4 rests directly on the parent material.

This division and order is further represented by four groups of soils, determined on the basis of the texture and consistence of the successive layers in the profile, as follows: (1) A group in which the soils are underlain by clay which is comparatively dense and impervious in layers 4, 5, and 6 of the generalized profile described; (2) a group including soils underlain by sand and gravel or comparatively loose and pervious material in layers 4, 5, and 6; (3) a group of soils having heavier or more clayey material in layers 4 or 5, whereas layer 6 is more pervious and less clayey; and (4) soils having a comparatively loose and pervious solum over indurated rock at a slight depth.

These groups are still further differentiated into soil series and types on the basis of differences in color, texture, structure, chemical composition, and thickness of the different layers.

Layer 3, representing the layer of maximum eluviation, and layer 4, representing the layer of maximum humic coloring, are the outstanding features of the complete or ideal regional profile. It appears, from extensive observations, that these layers reach their maximum development in thickness, intensity of coloring, and removal of inorganic colloids where the parent material is loose or incoherent sand and under conditions of moderately high average moisture, whereas minimum development has taken place where the parent material is either comparatively impervious clay or very dry sand and gravel. The normal thickness of layer 3, the gray highly eluviated layer, ranges from 4 to 8 inches and under exceptional conditions from 18 to 24 inches. The thickness of the brown or humic layer is commonly from 6 to 12 inches, with extremes ranging from 24 to 60 inches, although the base of this layer is not sharply marked in most places, especially where the parent material is loose sand. Under certain conditions layers 4 and 5 coalesce as a single layer. The maximum intensity of humic coloring is ordinarily at the top of the layer. There is a suggestion, from present field observations, that the darkest or umber color is present where the sand or gravel contains the largest amounts of calcium or magnesium carbonate, although it is apparent that a certain moisture condition is the dominant or controlling factor. The maximum content of iron oxide and maximum cementation in this layer appear to exist in soils like the Saugatuck and Ogemaw, where there is frequent saturation and a high water table but also a wide range of fluctuation in moisture conditions through the year. The maximum thickness and cementation occur in the Au Train and Wallace soils, and the darkest colors occur in the Longrie, Chatham, Kalkaska, and Blue Lake soils.

The thickness of surficial litter and duff under an old forest and under conditions of intermediate moisture normally ranges from 2 to 4 inches. This increases as the moisture conditions approach those of swamp, whereas, at the other extreme, little more than 1 inch of fluffy sandy mulch is on the driest sand plains. True humous soil, such as characterizes the subhumid prairie region of the United States and the gray-brown podzolic soils of the central and eastern parts, is absent or is developed only as a very thin layer. It is most noticeable, other factors and conditions being nearly equal, in places where the parent material is most limy or basic.

Layer 5 is weakly developed and does not show evidence of marked clay concentration, intense coloring, or ferric oxides developed in the soil-forming processes. A layer containing a higher percentage of clay or colloids than the parent material is less evident than in the southern part of the Lower Peninsula of Michigan and notably less than in the central and southern parts of the United States. However, a perceptible development of such a layer occurs in coarse gravelly calcareous material, and even in the heavy clays, like the Ontonagon soils, there is a slight intensification of the ferric oxide color over that of the parent material.

The depth to which carbonates have been removed in the soil-forming processes is in general between 30 and 40 inches, but it varies with the amount originally present, the texture of the parent material, and the surface relief. In the dense highly calcareous lacustrine clays

of the eastern part of the county complete removal has taken place to a depth ranging from 18 to 30 inches, whereas in some other soils, where the parent material consists predominantly of limestone gravel, cobbles, and boulders, as in the Rodman and Chatham soils, some limestone rock may remain throughout the profile. Phosphorus and potash are also removed in the soil-forming processes, especially in layer 3. Nitrogen is highest in the surface layer of organic accumulation, and it is also present in appreciable amounts in layer 4. Where the parent material is friable sandy clay drift and a compact layer 5 is present, a distinctly gray, pale-yellow, or pale-red leached layer occurs between layers 4 and 5. In most places the thickness of the solum is between 30 and 40 inches, and it appears to be no greater in the loose driest sands than in the densest most impervious clays.

The soils developed under conditions of poor drainage or excessive moisture have the following generalized profile: (1) A dark-gray or black surface layer representing an accumulation of organic matter; (2) a gray or drab layer, not at all or but slightly colored by organic matter; (3) a layer containing maximum clay and having a maximum degree of coherence or plasticity, or one containing maximum yellow or brown coloration and cementation from iron oxides; and (4) the substratum, or parent material. Leaching is greatest in layer 2 which reaches its greatest thickness in places where the parent material is sand. These soils are less completely leached of carbonates than the well-drained soils and are generally higher in fertility, measured by the total amount of nitrogen, calcium, phosphorus, and potash present, given the same parent material. Where the parent material is calcic or basic, the soils commonly show an alkaline or neutral reaction from the surface downward. Where the parent material is sand, layer 3 commonly shows a marked or even solid yellow or brown color from humic matter and iron compounds, and it may be more or less cemented into a hardpan. Where sand overlies comparatively impervious clay or indurated bedrock at a slight depth, an additional layer which is bleached or leached through permanent water-logging and lateral movement of water, is present at the line of contact.

The group of soils having incompletely developed profiles is represented mainly by recent alluvium in the valleys of the streams. Most of this material is of high average moisture content or occurs for the most part on swampy or semiswampy land. The alluvium is purely local in origin and commonly contains a high percentage of organic matter, sufficient to mask the rock color. These soils are classified as the Griffin and Erwen soils. A not uncommon feature of the deposits is alternate layers of mineral alluvium and muck (Kerston muck). The organic matter of these deposits is partly transported and partly accumulated in place. Belonging also in this group are the soils of recent dunes, beach and wind-laid deposits, the wave-washed strand along the Great Lakes, and some nearly barren hard rock surfaces. The soils are classified as Sauble, Deer Park, Shelldrake, and Alger soils. In this group the soil and the rock, or geological formation, are, of course, practically equivalent.

The organic soils are represented by a number of types which show considerable range in chemical and physical properties, although none of the soils appears to have developed quite so complete

alteration, or alteration to such great depths, as in the southern part of Michigan. Practically all are high in organic matter; that is, they contain 75 percent or more of combustible matter, and most of the deposits and the greater aggregate acreage appear to have accumulated in valleys or on flat plains and rock benches where drainage is stagnant rather than in lakes, although the lake-filled type is extensively represented. On the whole the deposits accumulated on wet plains and seepy slopes are not very thick. The peat in most places is underlain by clay, rock, or sand, and the lake deposits are not so commonly underlain by marl as in the southern part of the State.

More or less complete alteration, represented by a black or dark-brown color, destruction of the botanical character of the plant remains, and development of a loamy, granular, crumb structure in the oldest soils does not generally exceed a depth of 15 inches. In the most acid and peaty type of organic material, Greenwood peat, practically no alteration has taken place, although there is much greater fluctuation in the water table than in the more woody and less acid organic soils, Carbondale muck and Rifle peat. A small proportion of the organic material is nearly neutral in reaction and comparatively high in lime, but the greater part ranges from slightly to very strongly acid. In general, the most acid organic soils are associated with sands and the least calcareous rocks and glacial deposits, but in a number of places the acidity seems to depend on the height of the water table, stagnation or slow movement of drainage water, and kind of vegetation, since the adjacent soils and drift may be limy and the drainage waters alkaline. The family characteristics of organic soils are probably, in the last analysis, a function of the climate, as are the characteristics of families of mineral soils, with a modifying influence from the geology and physiography of the region in which they occur. Thus it seems probable that the oldest organic soils in this region cannot reach so complete a stage of decomposition as in regions farther south and that texture and consistence of the material differ because of differences in the plant species composing it.

There are 286 lakes, which range in size from 3 to more than 1,000 acres, and there is also a considerable area of stream bottoms, marsh, and permanently water-covered swamps. The lake waters which support vegetation are generally clear, with very little inorganic matter in suspension, and they are generally alkaline in reaction, owing to the presence of calcium and magnesium bicarbonates, although a few soft- and even acid-water lakes occur along the shore of Lake Superior. Most of the stream water is alkaline, even where the stream flows through the peat and muck swamps, and the water is colored from suspended or dissolved organic matter. In most of the bogs and swamps, occupied wholly or in part by such plants as leatherleaf, Labrador-tea and Sphagnum moss, the standing water is acid in reaction, as is also the water of lakes surrounded by leatherleaf bogs. In addition to the chemical composition, temperature, and depth of water, the character of the subaqueous soil is a factor influencing the kind of plant growth. Clean sand, hard rock, gelatinous peat, and coarse peat are common in the bottoms of lakes and marshes, but a marl bottom is rare.

The mineral soil types differentiated occur in a gradational series, according to variations in the moisture or drainage conditions under which the soil has developed. This gradational character of soil types is universal, so that, given the textural succession of layers and chemical or lithologic character of the parent material, and knowing the characteristics of the climate, the kinds of soil or their range in chemical and physical characteristics can be predicted. Under such conditions the limits established for each soil type in practical mapping must necessarily be arbitrary, and each soil type embraces soil of a transitional character.

In Alger County a moisture series can be recognized for soils derived from each of the following kinds of parent material: (1) Highly calcareous massive stony and sandy friable clayey drift, (2) stony noncalcareous clayey drift, (3) loose incoherent sands, (4) dense fine-grained lacustrine clays, (5) uniform silt and very fine sand, (6) sand over impervious clay, (7) sand over indurated bedrock, and (8) pervious unconsolidated gravel, cobbles, and stones.

The degree to which alteration of the parent material has taken place under the various moisture ranges possible is a function of the climate and the period of time that metamorphic processes have operated. A range in alteration is everywhere possible from practically no change, or geological equivalence, to the climax soil profile. In each of the groups of parent materials listed there is a fairly wide range of moisture conditions and a corresponding range or gradation in chemical and physical differences which constitute the basis of differentiation of the soils into types. For example, given parent material of sand, the conditions range from swamp in which the sand is covered with muck or peat to the driest condition where the surficial organic accumulation is extremely thin and where little development of gray and brown layers or leaching of iron oxide color has taken place.

The lithologic composition of the glacial deposits, which have directly influenced the chemical and physical character of the soils, bears, in turn, a close relation to the older hard-rock geological formations underlying the glacial material. Although the admixture of detritus from Canada is considerable, the drift is in general largely from local sources. The marked difference in the percentage of limestone gravel and boulders and, therefore, calcium and magnesium carbonates in the drift and soils in different localities, is in conformity with the direction of the ice movement, the absence of limestone and highly calcareous geologic formations on the north, and the predominance of limestone formations in the central and southern parts of the county. A strip of land extends from 2 to 10 miles inland from the shores of Lake Superior, in which the soils are influenced by a predominance of red and gray sandstone, quartzite, and acid igneous rocks in the parent material, together with a strong acid reaction in the solum. The soils become more basic southward, owing to the greater influence from limestone in the drift, especially where the deposits are thin over the bedrock. Locally thick sandy morainic deposits and thick assorted sandy outwash in the southern part of the county show less limestone influence than some of the drift near the shore of Lake Superior. Lacustrine deposits of silt and clay are not extensive in this county, but they are rather uni-

formly calcareous throughout their areal extent, and hence, as regards these deposits, the distribution of acid and alkaline soils bears little or no relation to the position of the older underlying geological formations or to the variation in lithologic character of the ice-laid drift.

The color tints of the soil layers and some chemical characteristics of the solum are also traceable indirectly to the local older geologic formations. The red color of the clayey drift and the salmon shade of much of the sand, both ice-laid and dune sand, as west of Grand Marais, are traceable to the red rock color and probably to red pre-glacial soil of the Lake Superior sandstone formation of Cambrian age, which lies along the shore of Lake Superior; whereas the color and chemical character of the clayey drift and soil in the southwestern part of the county, from Chatham southward, are traceable to the influence of a mixture of red Cambrian sandstone, calciferous glauconitic sandstone, and purer Ordovician limestones. The red color of the lacustrine silt and clay deposits, intensified to an Indian red when moist, in the clay soils like the Ontonagon, is also further reflected in the lavender tint and cinnamon color of the gray and brown layers of most of the associated soil types. The presence of glauconitic arenaceous limestone or calcareous sandstone is probably the cause of the peculiar brown color and high potash content in some of the soils, for example, Chatham stony loam.

The great diversity of soil types and their intimate association in many places in small bodies are traceable to the lithologic heterogeneity of the parent soil material and to the variations in thickness of comparatively pervious material over comparatively impervious clay or impenetrable bedrock, which results in a wide range in moisture conditions. There is also a diversity in the topographic expression of the Pleistocene formations, which include moraines, outwash plains, till plains, lake beds, and old shore lines.

The land formations were laid down during the last stages of the glacial period, so that the land surface is comparatively young. The minor topographic forms are almost entirely constructional, since streams have not yet had time to develop complete dendritic systems. Large areas, therefore, remain flat and undrained, so that a large total area of soils developed under conditions of excessive moisture has been possible. On the other hand, soils developed under conditions of low moisture have been possible because of the perviousness and thickness of many of the glacial deposits, notwithstanding the fact that the relief may be level. This is particularly true of the high-lying sands of the hardwood and pine plains, which represent both outwash deposits and wave-washed planate moraines. Various wet and dry conditions on the moraines above old lake levels are results largely of the difference in texture of the glacial debris rather than results of stream erosion or slope of the land surface.

The natural vegetation, as is universally true, has been a factor in the development of soil characteristics; but, as is also generally true, the vegetation is both a cause and an effect of soil differences. In this county the whole area, excepting the very small acreages of lake surface, marsh, and peat bog, was originally forested. Most of the forest cover was dense, even junglelike in some of the wetter situations, but in some of the drier situations, as in the dry sand

plains, there was a comparatively open growth of pines, with a shrub and herbaceous undergrowth. The woody character of the surface accumulation of organic matter, together with the thinness of the humous soil layer, are believed to be a function of the forest vegetation, and the underlying podzolized gray and brown, or orterde, layers, if not wholly, at least in part, are also attributable to the forest vegetation. Any constant relationship between the thickness or intensity of coloring of the layers and a particular type of forest vegetation is not apparent from observation, but the texture of the parent soil material and the average moisture content seem to be the dominant controlling factors. However, in places where hardwood forests and pine forests are contiguous on the same plain, with no observable difference in relief and lithologic character of the underlying parent material, the brown, or orterde, layer under the hardwood forest is darker and thicker than under the pine forest. The composition, texture, and other physical properties of the organic soils are clearly related to the kind of vegetation growing on these soils; and on the dry sand soils, such as the Rubicon, Grayling, and Wallace sands, the grasses and herbaceous vegetation, together with mosses, lichens, and shrubs, such as blueberry and sweetfern, have had an influence in determining a soil profile different from that of other soils. Influence of types of vegetation which preceded the present may be assumed, although too little is known about the histology of the soil profile to venture a statement of the specific character of such influences, except in peat deposits.

The progressive changes in the present soil profile are probably toward continued leaching and, therefore, increase in the thickness of the eluviated solum. In some of the sandy soils, the leaching process in the development of a gray layer beneath the forest mold is as nearly complete as possible, at least in thickness, so that uninterrupted processes would result in increment to the brown humic layer and further eluviation of the deeper layers. In the sandy clay parent material the present processes, if continued, could be expected to result in the intensification of the brown humic layer and the further development of a B horizon through addition of clay or in cementation and a consequent increase in a secondary layer of leaching or reduction between this and the brown humic layer. In the heaviest clays there should be an increase in the thickness of the gray eluviated layer and subsequent intensification of the brown humic layer which is at present weakly developed.

A suggestion of retrogression in profiles is evidenced in the partial destruction of the brown humic layer in ridges of deep dry sand which shows a profile developed under wetter conditions than exist at present, for example, in Wallace fine sand. Also, in a number of places, there is evidence of a rise in the water table, through continuous accumulation of water on flats and seeped slopes, and an accumulation of peat, with a consequent change, due to higher moisture content, in the profile of bordering soils which were formerly comparatively dry. As evidence of this, some of the larger swamps contain numerous low islands of dry sand, and jack pine grows in places on peats and wet mineral soils, such as the Newton and Saugatuck. On the other hand, there is evidence of a general physiographic change resulting in the lowering of the water table in wet flats and peat swamps through accentuated stream cut-

ting caused by land elevation and tilting. The extraordinary thickness, rust color, and cementation in the brown ortstein layer of Au Train loamy sand may be explained as a result of development under moister conditions than exist at the present time.

The soils of the dunes afford an illustration of rapid change caused by wind action, the blowing out in one place and deposition in another, so that the existing weakly developed profiles are obliterated in one place and buried in another. A deposit of wind-blown dust and very fine sand, ranging from 1 to 6 feet in thickness, has been spread over old lake-bed terraces at Grand Marais, and the soil is classified as Alger loam. An incipient soil profile is present, but changes are constantly taking place, owing to continued deposition.

SUMMARY

Alger County is in the north-central part of the Upper Peninsula of Michigan. The total area is 912 square miles.

The county lies in the glaciated region of the United States. The surface features consist of nearly level plateau plains and terraces thinly mantled with stony glacial drift; gently rolling hilly areas of morainic drift, intersected by broad swampy valleys; dry level outwash plains of sand and gravel; and lake-shore areas consisting of low beach ridges, sand dunes, marshes, swamps, and lake-shore cliffs. One large and three small islands lie off the shore from Munising.

The elevation above sea level ranges from approximately 600 feet, the level of Lake Superior, to a little more than 1,000 feet.

The land was originally densely forested. The most common trees were sugar maple, yellow birch, beech, hemlock, white pine, red (Norway) pine, jack pine, white cedar, spruce, balsam fir, and tamarack. A fairly large acreage of virgin hardwood forest remains, but all the pine land and the greater part of the hardwood and swamp land have been cut over.

The population of the county (1930) is 9,327.

Agriculture and lumbering are the principal industries. Transportation facilities consist of railways, lake steamships, and improved highways.

The climate is characterized by rigorous winters and short summers. The mean annual temperature is about 40° F., the average annual precipitation is 32.15 inches, and the average snowfall is more than 100 inches. The period between killing frosts at Grand Marais is 155 days and at Chatham is 82 days.

Farming began in the county about 1900. The principal crops grown are hay, oats, barley, field peas, and potatoes. Dairying is an important source of income on most farms. About 43,000 acres were in farms in 1930. It is estimated that potentially first-class agricultural land comprises approximately 15 percent of the total area of the county; second-class land, 40 percent; and third-class land, non-agricultural under present economic conditions, 45 percent. It is estimated that about 30 percent of the land is poorly drained or swamp land. The nonagricultural land is suitable for forestry, recreation parks, and game refuges.

The soils are characterized by great diversity in texture, drainage conditions, chemical composition, and productivity. Soils occur

which are loose incoherent dry sands, and others are composed of compact silt and clay. There are some highly calcareous or limestone soils in the southwestern part, but throughout the county the greater part of the soils are highly acid. Sands and sandy loams predominate, including about 85 percent of the acreage of mineral soils, and the acreage of silt loams and clay loams is negligible. A large percentage of the land in the western part of the county is excessively stony. The total area of organic soils (peats and mucks) comprises 19.1 percent of the land in the county.

The principal mineral soils that have fair or good natural drainage have been mapped in the Kalkaska, Au Train, Rubicon, Grayling, Hiawatha, Strongs, Blue Lake, Emmet, Munising, Trenary, Chatham, and Onota series.

The Trenary, Munising, and Chatham soils are extensive and constitute the greater part of the present and potential first-class agricultural land. They are naturally best adapted for the production of hay, small grains, and potatoes.

The Hiawatha and Emmet soils comprise the greater part of the hilly land, and the Kalkaska, Au Train, Grayling, and Rubicon soils comprise most of the sand soils of the nearly level sandy plains and valleys. These sandy soils are dry and of low or only medium fertility. They are not generally profitable for agriculture under present economic conditions but locally may constitute marginal or even profitable agricultural land. The Onota soils include most of the excessively stony land on the high sandstone plateau and rock benches of the northwestern and north-central parts of the county bordering Lake Superior.

The mineral soils occurring under conditions of poor drainage are classified in the Saugatuck, Ogemaw, Newton, and Munuscong series. These soils are of little value for agriculture at present on account of such factors as low fertility, stoniness, small size of the individual areas, and other causes.

The alluvial soils are classified in the Griffin and Ewen series. They are of small aggregate acreage and little agricultural value.

The mucks and peats are classified as the Carbondale, Rifle, Spalding, Kerston, Houghton, Greenwood, and Tahquamenon types. The Carbondale and Kerston mucks are the darker colored, less acid, and more productive types. Rifle peat is a peaty soil which is densely forested with tamarack, white cedar, and spruce. These three organic soils are of little value for cultivated crops, but they are capable of supporting a good growth of forest trees. The Spalding and Greenwood peats are highly acid raw peats which support a bog vegetation and black spruce forest. Houghton muck and Tahquamenon peat comprise slightly decomposed or raw peat. Most of the areas are marsh rather than swamp, and they support a growth of sedges and grasses.

The mineral soils having well-developed profiles belong to the podzol family. The gray and brown layers are weakly developed in the heavier textured soils. Alteration of the parent material by soil-forming processes generally extends to a depth ranging from 30 to 48 inches in the older mineral soils.

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